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Standard Operating Safety Guides

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MEMORANDUM

SUBJECT: Standard Operating Safety Guides, July 1988

FROM: Henry L. Longest II, Director
Office of Emergency and Remedial Response

Timothy Fields, Jr. (for)

TO: Regional Office Addressees

The enclosed Standard Operating Safety Guides, July 1988, replace the November 1984 edition. The guides have been updated and revised to reflect the experience EPA personnel have gained in responding to environmental incidents involving hazardous materials.

The Standard Operating Safety Guides are in accordance and consistent with the policies and procedures for employee health and safety contained in EPA's Health and Safety Manual, May 5, 1984. The current OSHA regulations (29 CFR 1910, Part 120) for hazardous waste workers has also been incorporated into these guides.

The guides are not meant to be a comprehensive safety manual for incident response. Rather, they provide information on health and safety to complement professional judgement and experience, and to supplement existing Regional Office safety procedures.

If you have any questions or comments concerning the guides, please contact Mr. Timothy Fields, Jr., Director, Emergency Response Division or Dr. Joseph Lafornara, Chief, Environmental Response Branch.

Addressees

Director, Environmental Services Division, Regions I, VI, and VII
Director, Office of Emergency and Remedial Response, Region II
Director, Hazardous Waste Management Division, Regions III and V
Director, Air and Waste Management Division, Region IV
Director, Waste Management Division, Region VIII
Director, Toxic and Waste Management Division, Region IX
Director, Hazardous Waste Division, Region X

cc Gene Lucero, Director, OWPE
Sylvia Lowrance, Director, OSW

STANDARD OPERATING SAFETY GUIDES

JULY 1988

U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF EMERGENCY AND REMEDIAL RESPONSE
EMERGENCY RESPONSE DIVISION
ENVIRONMENTAL RESPONSE BRANCH

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PART 1

ENVIRONMENTAL INCIDENTS

I. INTRODUCTION

An environmental incident involves a release or threat of a release of hazardous substances that pose an imminent and substantial danger to the public's health and welfare or the environment. The incident may be an emergency, requiring a prompt response, or a longer-term remedial action at an abandoned hazardous waste site. Regardless of how it happens, each incident presents special problems. Response personnel must evaluate these problems and determine an effective course of action to abate the situation.

Any incident represents a potentially hostile situation. Chemicals that are combustible, explosive, corrosive, toxic, or reactive, along with biological and radioactive materials can affect the general public or the environment as well as response personnel. Physical hazards may also be encountered. Workers may fall, trip, be struck by objects, or be subjected to danger from electricity and heavy equipment. Injury and illness may also occur due to the physical stress of response personnel. While the response activities needed at each individual incident are unique, there are many similarities. One is that all responses require protecting the health and ensuring the safety of response personnel.

II. EXPOSURE TO TOXIC SUBSTANCES

Toxic (including radioactive material and biological agents) or chemically active substances present a special concern because they can be inhaled, ingested, or be absorbed through or destructive to the skin. They may exist in the air, or due to site activities, become airborne. Liquids or sludges can splash on the skin. The effects of these substances can vary significantly. Ingested or inhaled the substances may cause no apparent illness or they can be fatal. On the skin they may cause no demonstrable effects. Other substances, however, may damage the skin or be absorbed through it, leading to systemic toxic effects.

Two types of potential exposures exist:

- Acute: Exposures occur for relatively short periods of time, generally minutes to 1-2 days. Concentrations of toxic air contaminants are high relative to their protection criteria. In addition to inhalation, airborne substances might directly contact the skin, or liquids and sludges may be splashed on the skin or into the eyes, leading to toxic effects.

- Chronic: Continuous exposure occurs over longer periods of time, generally months to years. Concentrations of inhaled toxic contaminants are relatively low. Direct skin contact by immersion, splash, or by contaminated air involves contact with substances exhibiting low dermal activity.

In general, acute exposures to chemicals in air are more typical in transportation accidents and fires, or releases at chemical manufacturing or storage facilities. High concentrations of contaminants in air usually do not persist for long periods of time. Acute skin exposures may occur when workers must be in close contact with the substances in order to control the release, for example, patching a tank car, off-loading a corrosive material, uprighting a drum, or to contain and treat the spilled material.

Chronic exposures are usually associated with longer-term removal and remedial operations. Contaminated soil and debris from emergency operations may be involved, soil and ground water may be polluted, or temporary impoundment systems may contain diluted chemicals. Abandoned waste sites typically represent chronic exposure problems. As activities start at these sites personnel engaged in certain activities (sampling, handling containers, or bulking compatible liquids) face an increased risk of acute exposures from splashes, or from vapors, gases, or particulates that might be generated.

At any specific incident, the hazardous properties of the materials may only represent a potential risk. For example, if a tank car of liquified natural gas is involved in an accident remains intact, the risk from fire and explosion is low. In other incidents, the risks to response personnel are high. For instance, when toxic or flammable vapors are being released from a ruptured tank truck. The continued health and safety of response personnel requires that the risks (real or potential) at an episode be assessed and appropriate measures instituted to reduce or eliminate the threat to response personnel.

III. HEALTH AND SAFETY OF RESPONSE PERSONNEL

To reduce the risks to personnel responding to hazardous substance incidents, an effective health and safety program must be developed and followed. As a minimum, a comprehensive worker health and safety program should address:

- Safe work practices.
- Engineered safeguards.
- Medical surveillance.
- Environmental and personnel monitoring.
- Personnel protective equipment.
- Education and training.
- Standard operating safety procedures.

As part of a comprehensive program, standard operating safety procedures provide instructions on how to accomplish specific tasks in a safe manner. In concept and principle, standard operating safety procedures are independent of the type of incident. At a particular incident they are adapted and modified to correspond to the safety requirements that are needed. For example, the requirement for personnel to wear protective equipment is an initial consideration for all incidents. The need and the type of equipment required is based on a case-by-case evaluation. Likewise, someone must make the first entry onto a site. The exact entry procedure to be used can only be determined after assessing the conditions prevailing at that incident.

The purpose of this document is to provide standard operating safety guides for protecting the health and safety of response personnel. The guidance included is not meant to be a comprehensive treatment of the subjects covered. Rather, it is meant to be used as an addition to, and to complement professional training, experience, and knowledge.

IV. U.S. EPA OCCUPATIONAL HEALTH AND SAFETY POLICIES

The U.S Environmental Protection Agency's (EPA) Occupational Health and Safety Staff is responsible for developing, supporting, and evaluating a program to protect the health and safety of EPA employees. The Standard Operating Safety Guides complement and supplement the policies, procedures, and practices contained in EPA's Occupational Health and Safety Manual (EPA Order 1440), particularly, Chapter 9, Hazardous Substances Responses, EPA Order 1440.2, Health and Safety Requirements for Personnel Engaged in Field Activities, and EPA Order 1440.3 , Respiratory Protection.

VI. U.S. OSHA HEALTH AND SAFETY REGULATIONS

The U.S. Occupational Safety and Health Administration (OSHA) has regulations governing employee health and safety at hazardous waste operations and during emergency responses to hazardous substance releases. These regulations (29 CFR 1910.120) contain general requirements for safety and health programs, site characterization and analysis, site control, training, medical surveillance, engineering controls, work practices along with personal protective equipment, exposure monitoring, informational programs, material handling, decontamination, emergency procedures, illumination, sanitation, and site excavation.

EPA's Standard Operating Safety Guides supplement and complement these regulations, but for specific legal requirements, OSHA's regulations must be used. Other OSHA regulations may pertain to employees working with hazardous materials or working at hazardous waste sites. These, as well as, state and local regulations must also be considered when developing worker health and safety programs.

PART 2

STANDARD OPERATING SAFETY PROCEDURES

I. INTRODUCTION

There are many procedures for performing the variety of tasks associated with a response to environmental incidents involving hazardous substances. These may be administrative, technical, or management-oriented. All of these procedures are intended to provide uniform instructions for accomplishing a specific task. In addition to other types of procedures, safety-oriented operating procedures are needed. The purpose of this document is to provide selected standard operating safety guides which can be used by other organizations to develop more specific operating safety procedures.

II. DEVELOPMENT OF STANDARD OPERATING SAFETY PROCEDURES

A major consideration in responding to accidental releases of hazardous substances or to abandoned hazardous waste sites, is the health and safety of response personnel. Not only must a variety of technical tasks be conducted efficiently, but they must be accomplished safely. Appropriately equipped and trained personnel, combined with standard operating procedures, help reduce the possibility of harm to response personnel.

Standard operating safety procedures should be developed and written by competent safety professionals. To be effective:

- They must be prepared in advance. Developing and writing safe, practical procedures is difficult to accomplish when done under the stress of responding to an incident.
- They must be based on the best available information, operational principles, and technical guidance.
- They must be field-tested, reviewed, and revised when appropriate.
- They must be understandable, feasible, and appropriate.
- All personnel involved in site activities must have access to copies of the safety procedures and be briefed on their use.

- Response personnel must be trained and periodically retrained in personnel protection and safety.

III. ADAPTATION TO SITE SPECIFIC RESPONSE ACTIVITIES

In concept and principle, standard operating safety procedures are generic and independent of the type of incident. They are adapted or modified to meet site-specific requirements. Each hazardous materials incident must be evaluated to determine its hazards and risks. Various types of environmental samples or measurements may initially be needed to determine the hazards or to provide additional information for continuing assessment. Personnel must go on-site to accomplish specific tasks. Efforts are required to prevent or reduce harmful substances from migrating from the site. Containment, cleanup, and disposal activities may be required.

All of these activities require that safety procedures be developed or existing procedures be adapted so that response personnel are protected.

IV. STANDARD OPERATING SAFETY GUIDES

The standard operating safety guides contained in this document consist of technical information that should be considered in developing standard operating safety procedures. For a given incident, the guides recommended herein should be adapted and modified to provide the safety criteria required to protect response personnel against the hazards created by that specific incident.

PART 3

HEALTH AND SAFETY REQUIREMENTS

I. INTRODUCTION

Personnel responding to environmental incidents involving hazardous substances may encounter a wide range of health and safety problems. Besides hazards associated with the physical, chemical, and toxicological properties of the materials involved, other safety concerns, such as electrical hazards, heat stress, cold exposure, faulty equipment, and construction dangers, can also have adverse effects on personnel.

To ensure the safety of response personnel, an effective, comprehensive health and safety program must be established and followed. This part discusses the minimum components that should be addressed in a health and safety program.

II. MEDICAL PROGRAM

To safeguard the health of response personnel, a medical program must be developed, established, and maintained. This program has two essential components: routine health care and emergency treatment.

A. Routine Health Care

At a minimum, routine health care and maintenance should consist of:

- Pre-employment medical examinations to establish the individual's state of health, baseline physiological data, and ability to wear personnel protective equipment.
- Annual examinations, of which, the frequency and content will be determined by the examining physician. The examination may vary depending on: the length and type of work assignment, the frequency of exposure, and the individual's physical condition.
- More frequent examinations (determined by the physician) due to the workers's assignment and potential exposure levels.

- Special medical examinations, care, and counseling in case of known or suspected exposures to toxic substances. Any special tests needed depend on the chemical substance to which the individual has been exposed.
- Termination examinations conducted at the end of employment or upon reassignment. The content of the examination should be similar to the baseline examination.

B. Emergency Medical Care and Treatment

The Medical Program must address emergency medical care and treatment of response personnel, including possible exposures to toxic substances and injuries resulting from accidents or physical hazards. The following items should be included in emergency care provisions:

- Name, address, and telephone number of the nearest medical treatment facility. This should be conspicuously posted. A map and directions for locating the facility, plus the travel time, should be readily available.
- The facility's ability to provide care and treatment of personnel exposed or suspected of being exposed to toxic (or otherwise hazardous) substances. If the facility lacks toxicological capability, arrangements should be made for consultant services.
- Administration arrangements for accepting patients.
- Arrangements to quickly obtain ambulance, emergency, fire, and police services. Telephone numbers and procedures for obtaining these services should be conspicuously posted.
- Emergency showers, eye wash fountains, and first aid equipment readily available on-site. Personnel should have advanced first aid and emergency lifesaving training.
- Provisions for the rapid identification of the substance to which the worker has been exposed (if this has not previously been done). This information must be given to medical personnel.

- Procedures for decontamination of injured workers and preventing contamination of medical personnel, equipment, and facilities.

- Protocols for heat stress and cold exposure monitoring, and working in adverse weather conditions.

- Medical evacuation requirements.

The EPA's Environmental Response Team's "Occupational Medical Monitoring Program Guidelines for SARA Field Activity Personnel", June 2, 1988, addresses specific medical monitoring concerns and procedures.

C. Maintenance of Records

Due to the nature and risk of the work associated with hazardous material incidents and that the potential exposure to harmful substances may have an adverse effects on an employee, it is essential that proper records be maintained and retained.

Medical records should contain the following information:

- Any occupational exposure.

- Employees use of respirators and personnel protective clothing.

- Any work-related injuries.

- Physician's written opinion of medical problems and treatment.

- Record of all medical examinations.

D. Indicators of Toxic Exposure

As part of the medical program, response personnel should be instructed in the signs and symptoms that might indicate potential exposure to toxic substances.
Some of these are:

- Observable by others
    - -- changes in complexion, skin discoloration

    - lack of coordination
    - changes in demeanor
    - excessive salivation
    - pupillary response
    - changes in speech pattern
    - breathing difficulties
    - difficulties with coordination
    - coughing
- Non-Observable by others
    - headaches
    - dizziness
    - blurred vision
    - cramps
    - irritation of eyes, skin, or respiratory tract
    - behavior changes

III. HEALTH AND SAFETY TRAINING

Safety and health training must be an integral part of the total response health and safety program. Safety training must be continuous and frequent for response personnel to maintain their proficiency in the use of equipment and their knowledge of safety requirements.

All personnel involved in responding to environmental incidents and who could be exposed to hazardous substances, health hazards, or safety hazards must receive safety training prior to carrying out their response functions. Health and safety training must, as a minimum, include:

- Use of personal protective equipment, for example, respiratory protective apparatus and protective clothing.

- Use of personal protective equipment, for example, respiratory protective apparatus and protective clothing.
- Safe work practices, engineering controls, and standard operating safety procedures.
- Hazard recognition and evaluation.
- Medical surveillance requirements, symptoms and signs which might indicate medical problems, and first aid.
- Site safety plans and plan development.
- Site control and decontamination.
- Use of monitoring equipment, if applicable.

Training must be as practicle as possible and include hands-on use of equipment and exercises designed to demonstrate and practice classroom instruction. Formal training should be followed by at least three days of on-the-job experience working under the guidance of an experienced, trained supervisor. All employees should, as a minimum, complete annually an 8 hour safety refresher training course. Health and safety training must comply with OSHA's training requirements as defined in 29 CFR 1910.120.

IV. QUALIFIED SAFETY PERSONNEL

Personnel responding to chemical incidents must make many complex decisions regarding safety. Making these decisions correctly requires more than elementary knowledge. For example, selecting the most effective personnel protective equipment requires not only expertise in the technical areas of respirators, protective clothing, air monitoring, physical stress, etc., but also experience and professional judgment.

Only a competent, qualified person (safety specialist) has the technical judgment to evaluate a particular incident and determine the appropriate safety requirements. It's through a combination of professional education, on-the-job experience, specialized training, and continual study, that the safety professional acquires the expertise to make sound decisions.

V. STANDARD OPERATING SAFETY PRACTICES

Standard operating safety procedures should include safety precautions and operating practices, that all responding personnel should follow. These would include:

A. Personal Precautions

- Eating, drinking, chewing gum or tobacco, smoking, or any practice that increases the probability of hand-to-mouth transfer and ingestion of material is prohibited in any area designated contaminated.

- Hands and face must be thoroughly washed upon leaving the work area.

- Whenever decontamination procedures for outer garments are in effect, the entire body should be thoroughly washed as soon as possible after the protective garment is removed.

- No facial hair which interferes with a satisfactory fit of the mask-to-face-seal is allowed on personnel required to wear respirators.

- Contact with contaminated or suspected contaminated surfaces should be avoided. Whenever possible, do not walk through puddles, leachate, discolored surfaces, kneel on ground, lean, sit, or place equipment on drums, containers, or the ground.

- Medicine and alcohol can potentiate the effects from exposure to toxic chemicals. Prescribed drugs should not be taken by personnel on response operations where the potential for absorption, inhalation, or ingestion of toxic substances exists unless specifically approved by a qualified physician. Alcoholic beverages should be avoided, in the off-duty hours, during response operations.

B. Operations

- All personnel going on-site must be adequately trained and thoroughly briefed on anticipated hazards, equipment to be worn, safety practices to be followed, emergency procedures, and communications.
- Any required respiratory protection and chemical protective clothing must be worn by all personnel going into areas designated for wearing protective equipment.
- Personnel on-site must use the buddy system when wearing respiratory protection. As a minimum, two other persons, suitably equipped, are required as safety backup during initial entries.
- Visual contact must be maintained between pairs on-site and safety personnel. Entry team members should remain close together to assist each other during emergencies.
- During continual operations, on-site workers act as safety backup to each other. Off-site personnel provide emergency assistance.
- Personnel should practice unfamiliar operations prior to doing the actual procedure.
- Entrance and exit locations must be designated and emergency escape routes delineated. Warning signals for site evacuation must be established.
- Communications using radios, hand signals, signs, or other means must be maintained between initial entry members at all times. Emergency communications should be prearranged in case of radio failure, necessity for evacuation of site, or other reasons.
- Wind indicators visible to all personnel should be strategically located throughout the site.
- Personnel and equipment in the contaminated area should be minimized, consistent with effective site operations.

- Work areas for various operational activities must be established.
- Procedures for leaving a contaminated area must be planned and implemented prior to going on-site. Work areas and decontamination procedures must be established based on expected site conditions.

VI. SITE SAFETY PLAN

A site safety plan must be developed and implemented for all phases of site operations. The safety plan should address the safety and health hazards of each phase of the site operation, as well as specify the requirements and procedures for employee protection.

- The plan must be written and posted on site.
- All personnel must be familiar with standard operating safety procedures and any additional instructions and information contained in the Site Safety Plan.
- All personnel must adhere to the information contained in the Site Safety Plan.

A more detailed description of site safety plans and what they must contain is in Part 4.

VII. SUMMARY

The health and safety of response personnel are major considerations in all response operations. All site operation planning must incorporate an analysis of the hazards involved and procedures for preventing or minimizing the risk to personnel.

PART 4

SITE SAFETY PLAN

I. INTRODUCTION

The purpose of the site safety plan is to establish policies and procedures for protecting the health and safety of response personnel during all operations conducted at an incident. It contains information about the known or suspected hazards, routine and special safety procedures that must be followed, and other instructions for safeguarding the health of the responders.

A site safety plan shall be prepared and reviewed by qualified personnel for each hazardous substance response. Before operations at an incident commence, all safety aspects of site operations should be thoroughly examined. A safety plan is then written based on the anticipated hazards and expected work conditions. The plan should be conspicuously posted or distributed to all response personnel and discussed with them. The safety plan must be periodically reviewed to keep it current and technically correct.

In non-emergency situations, for example, long-term remedial action at abandoned hazardous waste sites, safety plans are developed simultaneously with the general work plan. Workers can become familiar with the plan before site activities begin. Emergency responses generally require the use of a generic safety plan, standing standard operating procedures, and special verbal instructions until (if time permits) a plan can be written.

The plan must contain safety requirements for routine (but hazardous) response activities and also for unexpected site emergencies. The major distinction between routine and emergency site safety planning is the ability to predict, monitor, and evaluate routine activities. A site emergency is unpredictable and may occur anytime.

II. CATEGORIES OF HAZARDOUS MATERIALS RESPONSES

Three general categories of response exist: emergencies, hazardous waste site investigations and remedial actions. Although considerations for personnel safety are generic and independent of the response category, in scope, detail, and length safety requirements and plans vary considerably. These variations are generally due to the reason for responding (or category of response), information available, and the severity of the incident with its concomitant dangers to the responder.

A. Emergencies

1. Situation:

Emergencies generally require prompt action to prevent or reduce undesirable effects. Immediate hazards of fire, explosion, and release of toxic vapors or gases are of prime concern. Emergencies vary greatly in respect to types and quantities of material, hazards, numbers of responders involved, type of work required, population affected, and other factors. Emergencies usually last from a few hours to a few days.

- Information available: Varies from none to much. Usually, information about the materials involved and their associated hazards, is quickly obtained in transportation related incidents, or incidents involving fixed facilities. Determining the substances involved in other incidents, such as mysterious spills or illegal dumping requires considerable time and effort.

- Time available: Little time. Generally requires prompt action to bring the incident under control.

- Reason for response: To implement prompt and immediate actions to control dangerous or potentially dangerous situations.

2. Effects on Plan

In emergencies, time is not available to write lengthy and detailed safety plans. Therefore, general safety plans for emergency response (generic plans) are developed prior to responding and are implemented when an emergency occurs.

Responding organizations must rely on their existing generic safety plan and written standard operating safety procedures adapted to meet incident-specific conditions, and the use of verbal safety instructions.

Since there is a heavy reliance on verbal communications, an effective system to keep all responders informed must be established. Whenever possible, these incident-specific instructions should be written and posted.

B. Hazardous Waste Site Investigations

1. Situation:

In non-emergency responses, for example, preliminary inspections at abandoned wastes sites or more comprehensive waste site investigations, the objective is to determine and characterize: the chemicals and hazards involved; the extent of contamination; and risks to people and the environment. In general, initial inspections, detailed investigations, and extent of contamination surveys are limited in the activities that are required and number of people involved. Initial or preliminary inspections generally require 1-5 days. Complete investigations may last over a longer period of time (months).

- Information available: Much background information is often available, but may not be specific enough for making initial safety decision. On-site information more fully developed through additional surveys and investigations.
- Time available: In most cases adequate time is available to make a preliminary evaluation of the site's characteristics and to develop a written site-specific safety plan.
- Reason for response: To gather data to verify or refute existing information, to gather information to determine scope of subsequent investigations, or to collect data for planning remedial action.

2. Effects on Plan:

Sufficient time is available to determine, on a preliminary basis, the hazards anticipated and other conditions associated with the site and to write initial safety plans. In scope and detail, these plans tend to be brief and contain safety requirements for specific on-site work relevant to collecting data. As information is developed through additional investigations, the safety plan is modified and, if necessary, more detailed and specific requirements added.

C. Remedial Actions

1. Situation:

Remedial actions are cleanups which may take many years to complete. They commence after more immediate problems at an emergency have been controlled, or they involve the mitigation of hazards and restoration of abandoned hazardous waste sites. Numerous activities are required involving the efforts of many people, a detailed logistics and support base, extensive equipment, and more involved work activities.

- Information available: Much known about on-site hazards.
- Time available: Ample time for work planning.
- Reason for response: Systematic and complete control, cleanup, and restoration.

2. Effects on Plan:

Since ample time is available before work commences, site safety plans tend to be comprehensive and detailed. From prior investigations much detail may be known about the materials or hazards at the site and extent of contamination.

III. PRELIMINARY SITE EVALUATION AND SAFETY PLAN

A preliminary evaluation of a hazardous waste site's characteristics must be performed, by a qualified person, prior to anyone going on the site. The information obtained is used to determine the appropriate health and safety control procedures needed to protect initial entry team personnel from identified or suspected hazards. After initial site entry, a more detailed evaluation of site characteristics is made based upon information collected by the entry team. The preliminary site safety plan is then modified and refined.

Of immediate concern are known or expected substances that are Immediately Dangerous to Life and Health (IDLH) through skin absorption or inhalation, or other conditions that may cause death or serious injury. Some examples of these conditions are: fire or explosive potential, visible vapor clouds, radioactive labeled material, and confined space entry.

A preliminary evaluation of the site's characteristics shall include:

- Incident location and name.
- Site description, topography, and size.
- Descriptions of the activities or tasks to be done.
- Duration of planned of planned activities.
- Site accessibility.
- Hazardous substances and health hazards involved or expected.
- Chemical, physical. and toxicological properties of the hazardous substances involved.
- Behavior and dispersion of material involved.
- Availability and capabilities of emergency assistance.

Additional information that might be useful is:

- Types of containers, storage, or transportation methods.
- Prevailing weather condition and forecast.
- Surrounding populations and land use.
- Ecologically sensitive areas.
- Facility records.
- Preliminary assessment reports.
- Off-site survey results.

The information initially available, collected during a preliminary inspection, or obtained through subsequent investigations provides a basis for developing a detailed, site-specific safety plan. This type of information is then used along with the reason for responding to develop a comprehensive safety plan.

The safety plan is tailored to the conditions imposed by the incident and to its environmental setting. As work progresses and as additional information becomes available, the safety plan is reviewed, modified, and kept current.

IV. GENERAL REQUIREMENTS FOR ROUTINE OPERATIONS

Routine operations are all those activities that may be required in responding to an emergency or a remedial action at a hazardous waste site in order to identify, evaluate, and control (including cleanup) the incident. These activities may involve a high degree of risk, but are standard operations generally involved in responding to that type of incident.

Safety practices for routine operations closely parallel accepted procedures used in industrial hygiene and industrial safety. Whenever a hazardous incident progresses to the point where operations become more routine, the associated site safety plan becomes a more refined document.
As a minimum, the following must be included as part of the site safety plan for routine operations.

- Key Personnel and Alternates

  The plan must identify the incident manager as well as the site safety and health officer (and alternates) and any other personnel responsible for site safety. It should also identify key personnel associated with other site operations. The names, telephone numbers, addresses, and organizations of these people must be listed in the plan and posted in a conspicuous place.

- Known Hazards and Risks

  All known or suspected physical, biological, radiological, or chemical hazards must be described. It is important that all health related data be kept up-to-date. As air, water, soil, or hazardous substance monitoring and sampling data becomes available, it must be evaluated, significant risk or exposure to workers noted, potential impact on public assessed, and changes made in the plan. These evaluations need to be repeated frequently since much of the plan is based on this information.

- Routine or Special Training Requirements
  Personnel must be trained not only in general safety procedures and use of safety equipment, but in any specialized work they may be expected to do.

- Levels of Protection

  The Levels of Protection to be worn at locations on-site or by work functions must be designated. This includes the specific types of respirators and type of chemical protective clothing to be worn for each level. No one shall be permitted in areas requiring personnel protective equipment unless they have been trained in its use and are wearing it.

- Site-Specific Medical Requirements

  Specialized medical requirements should be determined when unusual hazards are expected to be encountered.

- Environmental Surveillance Program

  A program to monitor site hazards must be implemented. This would include air monitoring and sampling, and other kinds of media sampling at or around the site that would identify chemicals present, their hazards, possible routes of migration off-site, and associated safety requirements.

- Work Areas

  Work areas (exclusion zone, contamination reduction zone, and support zone) need to be designated on the site map and the map posted. The size of zones, zone boundaries, and access control points into each zone must be marked and made known to all site workers.

- Site Control Procedures

  Control procedures must be implemented to prevent unauthorized access. Site security procedures - fences, signs, security patrols and check-in procedures - must be established. Procedures must also be established to control authorized personnel into work zones where personnel protection is required.

- Decontamination

  Decontamination procedures for personnel and equipment must be established. Arrangements must also be made for the proper disposal of contaminated material, solutions, and equipment.

- Emergency Response Plan

  A plan for responding safely and effectively to emergency situations that might develop at the site must be developed and included as part of the overall site safety plan.

- Confined Space Entry

  Procedures to assure the safety of personnel who may have to make confined space entry must be established.

- Weather-Related Problems

  Weather conditions can affect site work. Temperature extremes, high winds, precipitation, and storms, can impact on personnel safety. Work practices must be established to protect workers from the effects of weather and shelters provided, when necessary. Temperature extremes especially heat and its effect on people wearing protective clothing, must be considered and procedures established to monitor for and minimize heat stress.

V. ON-SITE EMERGENCIES

The plan must address site emergencies-occurrences that require immediate actions to prevent additional problems or harm to responders, the public, property, or the environment. In general, all responses present a degree of risk to the workers. During routine operations risk is minimized by establishing good work practices and using personnel protective equipment. Unpredictable events such as fire, chemical exposure, or physical injury may occur and must be anticipated. The plan must contain detailed information for managing these contingencies.

To accomplish this, the contingency plan must:

- Establish Site Emergency Procedures
    - List the names and emergency functions of on-site personnel responsible for emergency actions along with the special training required.
    - Post the location of nearest telephone (if none at site).
    - Provide alternative means for emergency communications.
    - Provide a list of emergency services organizations that may be needed. Names, telephone numbers, and locations must be posted. Arrangements for using emergency organizations should be made beforehand. Organizations that might be needed are:
        - Fire and Rescue Agency
        - Police Department
        - Health Department
        - Explosive experts
        - Local hazardous material response units
        - Emergency Services offices
        - Radiation experts
    - Address and define procedures for the rapid evacuation of workers. Clear, audible warning signals should be established. Well-marked emergency exits must be located throughout the site, as well as internal and external communications plans developed.
    - A complete list of emergency equipment should be attached to the safety plan. This list should include emergency equipment available on-site, as well as all available medical, rescue, transport, fire-fighting, and mitigative equipment available off-site.

- Address emergency medical care.
    - Determine location of nearest medical or emergency care facility and determine their capability to handle chemical exposure cases.
    - Arrange for, in advance, treating, admitting, and transporting of injured or exposed workers.
    - Post the location of medical or emergency care facilities, required travel time, directions, and telephone number.
    - Determine location of local physician's office, along with travel directions, hours of availability, and post telephone number if other medical care is not available.
    - Determine nearest ambulance service and post telephone number.
    - List the names of responding organization's physicians, safety officers, or toxicologists and telephone number. Also include nearest poison control center, if applicable.
    - Maintain accurate records on any exposure or potential exposure or injuries to site workers during an emergency (or routine operations).
- Advise workers of their duties during an emergency. In particular, it is imperative that the site safety officers, standby rescue personnel, decontamination workers, and emergency medical technicians practice emergency procedures.
- Incorporate into the plan, procedures for the decontamination of injured workers and for their transport to medical care facilities. Contamination of transport vehicles, medical care facilities, or of medical personnel may occur and should be addressed in the plan. Whenever feasible these procedures should be discussed with appropriate medical personnel in advance of operations.
- Establish procedures in cooperation with local and state officials for evacuating residents who live near the site.

VI. IMPLEMENTATION OF THE SITE SAFETY PLAN

The site safety plan, (standard operating safety procedure or a generic safety plan for emergency response) must be written to avoid misinterpretation, ambiguity, and mistakes that can result from verbal orders. The plan must be reviewed and approved by qualified personnel. Once the safety plan is implemented, it needs periodic examination and modification, if necessary, to reflect any changes in site work and conditions.

When there is more than one organization involved at the incident, the development of a safety plan should be a coordinated effort among the various agencies. Once the plan has been reviewed and approved by a qualified safety professional, lead personnel from each organization should sign the plan to document that they are in agreement with the provisions as well as to verify that their organization will follow it accordingly.

A safety and health officer must be appointed to ensure that the requirements of the safety plan are implemented. The safety officer has the authority to halt all operations if conditions become unsafe. In addition, the safety officer is responsible for instructing personnel on the provisions of the safety plan. Frequent safety meetings should be held to keep personnel informed about site hazards, changes in operating plans, modifications of safety requirements, and for any additional exchanges of information. All those on site must comply with the provisions set forth in the safety plan.

Frequent audits by the incident manager or the safety officer should be made to determine compliance with the plan's requirements. Any deviations should be brought to the attention of the incident manager and any deficiencies corrected. Modifications in the plan should be reviewed and approved by appropriate personnel.

VII. ANNEXES TO PART FOUR

Annex 1 is a summary of the U.S. Occupational Safety and Health Administration's requirements (20 CFR 1910.120) for: 1) the preliminary characterization that must be performed, by a qualified person, prior to the initial entry onto a hazardous waste site, and 2) the minimum requirements for a site safety and health plan.

The Incident Safety Check off List, Annex 2, is used by members of the U.S. EPA's Environmental Response Team when responding to an incident. It is not a health and safety plan, but an individuals record of incident related safety procedures or requirements. Other organizations might want to use a similar type of safety check off list to have a historical record of an individual's safety experience.

Annex 3 is the Table of Content for the Environmental Response Team's Field Operating Safety Procedures, Site Health and Safety Plan. The Table of Contents is a good summary of the information that must be in a site safety plan.

ANNEX 1

SUMMARY OF THE U.S. OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION'S REQUIREMENTS FOR PRELIMINARY EVALUATION AND SITE SAFETY AND HEALTH PLANS

(Interim Final Rule, Aug. 10, 1988)

PRELIMINARY EVALUATION: Prior to entering a site, the following information must be obtained. In addition, all suspected conditions that are Immediately Dangerous to Life and Health (IDLH) shall be identified.

- Site location and size.
- Description of response activities or job function.
- Planned duration of employee activity.
- Site topography.
- Site accessibility by air and roads.
- Pathways for hazardous substance dispersion.
- Present status and capabilities of emergency response teams for employee on-site emergencies.
- Hazardous substances involved or expected at the site and their chemical and physical properties.

SITE SAFETY AND HEALTH PLAN: Is part of the overall Safety and Health Program and shall be available on-site for employee inspection. It must include:

- Name of key personnel and alternates, and health and safety personnel.
- Task/operation safety and health risk analysis.
- Employee training.
- Personal protective equipment to be used.
- Frequency and types of air monitoring, personnel monitoring, and sampling techniques.
- Site control measures.
- Decontamination procedures.
- Site standard operating procedures.
- Site contingency plan.
- Confined space entry procedures.
- Medical surveillance program.

NOTES:

1. Pre-entry safety briefings shall be held prior to initiating any site activities.
2. Inspections shall be conducted by the Site Safety and Health Supervisor.

INCIDENT SAFETY CHECK OFF LIST

I. BEFORE FIELD ACTIVITY

_______________ Employee

1. **Incident:** Site ____ City ____ State ____
Response Dates ____

2. **Activity Description:** Site Evaluation ____ Containment ____ Well Drilling ____ Facility Inspection ____
Sampling - Air ____ Water ____ Drum ____ Soil ____ Residential ____ Other ____

3. **Type of Response:** Spill ____ Fire ____ Site ____ Train ____ Other ____

4. **Site Topography:** Mountains ____ Rivers ____ Valley ____ Rural ____
Suburban ____ Level ____ Slopes ____ Unknown ____

5. **Incident Safety Plan:**
Region ____ Reviewed ____
ERT ____ Briefed ____
Facility ____ Not Developed ____

6. **Site Accessibility:**
Road: Good ____ Air: Good ____
Fair ____ Fair ____
Poor ____ Poor ____

7. **Suspected chemical (s) and pathway with source (s) involved:** (A) ____
(B) ____ (C) ____ (D) ____

8. **Emergency Response Teams Present for First Aid, etc.** Yes ____ No ____

9. **Protective Level (s) Selected:** (A) ____ (B) ____ (C) ____ (D) ____
(a) If Level "C" - 1. Identify Canister ____
(b) If Level "D" - **JUSTIFY:**

10. **SCBA Identify Buddy System:** Office/Name ____

11. **Last Response:** (a) Level Used: (A) ____ (B) ____ (C) ____ (D) ____
(b) Medical Attention/Exam Performed: Yes ____ No ____

II. AFTER RESPONSE

1. **Protective Level Used:** (A) ____ (B) ____ (C) ____ (D) ____
a. Level "C" - identify canister: ____
b. Level "D" - **JUSTIFY:**
c. Level B or C skin protection: Tyvek ____ Tyvek/Saran ____ Acid/Rain ____ Other ____

2. **List possible chemical exposure:** **Same as above:** ____ (A) ____
(B) ____ (C) ____ (D) ____

3. **Equipment Decontamination:**

	(a) clothing	(b) respirator	(c) monitoring
Disposed:	____	____	____
Cleaned:	____	____	____
No Action:	____	____	____

4. **Approximate time in exlusion area:** ____ hours per day for ____ days

5. **Was medical attention/exam required for this response:** Yes ____ No ____

Part I: DATE PREPARED: ____ **Reviewed by** ____ **Date** ____
Part II: DATE PREPARED: ____ **Reviewed by** ____ **Date** ____

ANNEX 3

SITE HEALTH AND SAFETY PLAN

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PART 5

INITIAL SITE SURVEY AND RECONNAISSANCE

I. INTRODUCTION

The team initially entering the site is to accomplish one or more of the following objectives:

- Determine the hazards that may exist affecting public response personnel, the public, and the environment.
- Verify existing information or obtain new information about the incident.
- Evaluate the need for prompt action to mitigate the incident.
- Collect additional information to determine the safety requirements for personnel entering the site.

Before the team enters the site, as much information as possible should be collected, depending on the time available, concerning the type or degree of hazards, and risks which may exist. Based upon available information (shipping manifests, transportation placards, existing records, container labels, witnesses, etc.) or from off-site studies, the team assesses the hazards, determines the need to go on-site, and identifies initial safety requirements.

II. PRELIMINARY ON-SITE EVALUATION

The initial objective of an on-site survey is to determine, on a preliminary basis, hazardous or potentially hazardous conditions. The main effort is to rapidly identify immediate hazards that may affect response personnel, the public, or the environment. Of major concern are the real or potential dangers from fire, explosion, airborne contaminants, radiation, and to a lesser degree, oxygen deficient atmospheres.

A. Organic Vapors and Gases

If the type of organic substance involved in an incident is known and the material is volatile or can become airborne, air measurements for organics should be made with one or more appropriate, properly calibrated survey instruments.

When the presence or types of organic vapors/gases are unknown, instruments such as a photoionization detectors (PID) and flame ionization detectors (FID) operated in the total readout mode or as a chromatograph, should be used to detect organic vapors.

Until specific constituents can be identified, the readout indicates total airborne substances to which the instrument is responding. Identification of the individual vapor/gas constituents may permit the instruments to be calibrated to these substances and used for more specific and accurate analysis.

Sufficient data should be obtained during the initial entry to screen the site for various levels of organic vapors. These gross measurements may be used on a preliminary basis to: 1) determine levels of personnel protection, 2) establish site work zones, and 3) map selected candidate areas for more thorough qualitative and quantitative studies.

Very high readings on PIDs or FIDs may also indicate the possible displacement of oxygen or the presence of combustible vapors.

B. Inorganic Vapors and Gases

The number of direct reading instruments with the capability to detect and quantify non-specific inorganic vapors and gases is extremely limited. Presently, PIDs have very limited detection capability while PIDs have none. (See Appendix I for characteristics). If specific inorganics are known or suspected of being present, measurements should be made with appropriate instruments, if available. Colorimetric tubes are only practical if the substances present are known or can be narrowed to a few.

C. Radiation

A radiation survey should be done as part of the initial characterization at abandoned hazardous waste site and at hazardous material accidents whenever there is any possibility that radioactive materials could be involved. If no radiation is detected during the initial survey, subsequent surveys should be made at waste sites to make certain that the initial monitoring results were correct.

Normal background exposure-rate for gamma radiation is approximately 0.01 to 0.02 milliroentgen per hour (mR/hr) or 10 to 20 microroentgen per hour (µR/hr) on sensitive gamma survey instruments. Work can continue with elevated radiation exposure-rates; however, if the exposure-rate increases to 3-5 times above gamma background, a qualified health physicist should be consulted.

At no time should work continue with an exposure rate of 1 mR/hr or above without the advice of a health physicist. EPA's Office of Air and Radiation has radiation specialists in each Region, as well as at Headquarters, Montgomery, Alabama, and Las Vegas, Nevada, to assist. The absence of gamma readings above background should not be interpreted as the complete absence of radioactivity. Radioactive materials emitting low-energy gamma, alpha, or beta radiation may be present, but for a number of reasons may not cause a response on the instrument. Unless airborne, these radioactive materials should present minimal hazard, but more thorough surveys should be conducted as site operations continue to completely rule out the presence of any radioactive material.

D. Oxygen Deficiency

Normal air contains about 20.5% by volume of oxygen. At or below 19.5% oxygen, air-supplying respirators are needed. Oxygen measurements are of particular importance for work in enclosed spaces, low-lying areas, or in the vicinity of accidents that have produced heavier-than-air vapors which could displace ambient air. These oxygen deficient areas are also prime locations for taking additional organic vapor and combustible gas measurements, since the air has been displaced by other substances. Oxygen-enriched atmospheres increase the potential for fires by their ability to contribute to combustion or to chemically react with flammable compounds and promote auto ignition.

E. Combustible Gases

The presence or absence of combustible vapors or gases must be determined. If readings approach or exceed 10% of the lower explosive limit (LEL), extreme caution should be exercised in continuing the investigation. If readings approach or exceed 25% LEL, personnel should be withdrawn immediately. Before resuming any on-site activities, project personnel in consultation with experts in fire or explosion prevention must develop procedures for continuing operations.

F. Visual Observations

While on-site, the initial entry team should make visual observations which would help in evaluating site hazards. Biological indicators such as dead fish or other animals or stressed vegetation may indicate the presence of hazardous materials. Land features; wind direction; labels on containers indicating explosive, flammable, toxic, or corrosive materials; conditions conducive to splash or contact with unconfined liquids, sludges, or solids; and other general conditions may also provide some clues as to what hazards are present.

G. Direct-Reading Instruments

A variety of toxic air pollutants, (including organic and inorganic vapors, gases, or particulates) can be generated at an abandoned waste sites. Fires at chemical manufacturing, storage, reprocessing, or formulating facilities; fires involving pesticides, and many other incidents also can generate air contaminants. Direct-reading field instruments may be able to detect and quantify some air contaminants, but they cannot detect or measure all substances. Thus, negative readings on instruments should not be interpreted as the complete absence of airborne toxic substances. Verification of negative results can only be done by collecting air samples and having them analyzed in a laboratory using more sophisticated analytical techniques.

III. OTHER CONSIDERATIONS

A. Initial Surveys

In general, the initial entry is considered a relatively rapid screening process for collecting preliminary data on site hazards. The time needed to conduct the initial survey depends on the urgency of the situation, type of incident, information needed, size of site, availability of resources, and Level of Protection required for initial entry personnel. Consequently, initial surveys may need hours or days to complete and may consist of more than one entry.

B. Priority for Initial Entry Monitoring

The primary concern of initial entry personnel are atmospheric conditions which could affect their immediate safety. These conditions are airborne toxic substances, ignitable gases or vapors, oxygen depleted atmospheres, and ionizing radiation. Priorities for monitoring these potential hazards should be established after a careful evaluation of conditions.

When the type of material involved in an incident is identified and its release into the environment suspected or known, the material's chemical or physical properties and the prevailing weather conditions may help determine the order of monitoring. An unknown substance or situation presents a more difficult monitoring problem.

In general, for poorly-ventilated spaces - buildings, ship's holds, boxcars, or bulk tanks - which must be entered, combustible vapors or gases and oxygen-deficient atmospheres should be monitored first with team members wearing, as a minimum, Level B protective equipment (Levels of Protection are described in Part 6). Toxic gases or vapors and radiation, unless known to be absent, should be measured next.

For open, well-ventilated areas, combustible gases and oxygen deficiency are lesser hazards, and require lower priority. However, areas of lower elevation on-site (such as ditches and gulleys) and downwind areas may have combustible gas mixtures. In addition, there may be toxic vapors or gases present and lack of sufficient oxygen to sustain life. Entry teams should approach and monitor these areas, whenever possible, from an upwind direction.

C. Periodic Monitoring

The monitoring surveys made during the initial site entry phase are a preliminary evaluation of atmospheric hazards. In some situations, the information obtained may be sufficient to preclude additional monitoring, for example, a chlorine tank determined to be releasing no chlorine. Materials detected during the initial site survey call for a more comprehensive evaluation of hazards and analyses for specific components. A program must be established for monitoring, sampling, and evaluating hazards for the duration of site operations. Since site activities and weather conditions change, a continuous program to monitor the ambient atmosphere must be implemented utilizing a combination of stationary sampling equipment, personal monitoring devices, and periodic area monitoring with direct-reading instruments.

D. Off-Site Monitoring and Sampling

Whenever possible, atmospheric hazards in the areas adjacent to the on-site zone should be monitored with direct-reading instruments, and air samples should be taken before the initial entry for on-site investigations. Negative instrument readings off-site should not be construed as definite indications of on-site conditions, but only as another piece of information to assist in the preliminary evaluation.

E. Monitoring Instruments

It is imperative that personnel using monitoring instruments be thoroughly familiar with their use, limitations, and operating characteristics. All instruments have inherent constraints in their ability to detect and/or quantify the hazards for which they were designed. Unless trained personnel use instruments and assess data readout, air hazards can be grossly misinterpreted, endangering the health and safety of response personnel. In addition, only instruments approved for use in hazardous locations should be used, unless ignitable gases or vapors have been determined to be absent.

F. Ambient Atmospheric Concentrations

Any indication of atmospheric hazards - toxic substances, ignitable gases, lack of oxygen, and radiation - should be viewed as a sign to proceed with care and deliberation. Readings indicating non-explosive atmospheres, low concentrations of toxic substances, or other conditions may change rapidly, concomitantly changing the associated risks. Extreme caution should be exercised in continuing surveys when any atmospheric hazards are indicated.

TABLE 5-1

ATMOSPHERIC HAZARD ACTION GUIDES

MONITORING EQUIPMENT	HAZARD	LEVEL	ACTION
Combustible Gas Indicator	Explosive	< 10% LEL	Continue monitoring with caution.
		10-25% LEL	Continue monitoring, but with extreme caution, especially as higher levels are encountered.
		≥ 25% LEL	Explosion hazard! Withdraw from area immediately.
Oxygen Concentration		< 19.5%	Monitor wearing SCBA. NOTE: Combustible gas readings not valid in atmospheres < 19.5% oxygen.
		19.5-25%	Continue monitoring with caution. SCBA not needed based only on oxygen content.
		> 25%	Discontinue monitoring. Fire potential! Consult specialist.
Radiation Survey Instrument	Gamma Radiation	< 1 mR/hr	Continue monitoring. Consult a Health Physicist.
		≥ 1 mR/hr	Continue monitoring only upon the advice of a Health Physicist.

TABLE 5-1 (Continued)

ATMOSPHERIC HAZARD ACTION GUIDES

MONITORING EQUIPMENT	HAZARD	LEVEL	ACTION
Colorimetric Tubes	Organic & inorganic vapors/gases	Depends on chemical	Consult reference manuals for air concentration vs. toxicity data.
Photoionization Detector	Organic vapors/gases	Depends on chemical	Consult reference manuals for air concentration vs. toxicity data.
Flame Ionization Detector	Organic vapors/gases	Depends on chemical	Consult reference manuals for air concentration vs. toxicity data.

NOTE: The correct interpretation of any instrument readout is difficult. If the instrument operator is uncertain of the significance of a reading, especially if conditions could be unsafe, a technical specialist should immediately be consulted. Consideration should be given to withdrawing personnel from the area until approval, by the safety officer, is given to continue operations.

PART 6

LEVELS OF PROTECTION

I. INTRODUCTION

Response personnel must wear protective equipment when there is a probability of contact with hazardous substances that could affect their health. This includes vapors, gases, or particulates that may be generated by site activities, and direct contact with skin-affecting substances. Full facepiece respirators protect lungs, gastrointestinal tract, and eyes against airborne toxicants. Chemical-resistant clothing protects the skin from contact with skin destructive and absorbable chemicals. Good personal hygiene limits or helps prevent ingestion of material.

Equipment to protect the body against contact with known or anticipated toxic chemicals has been divided into four categories according to the degree of protection afforded:

- Level A: Should be worn when the highest level of respiratory, skin, and eye protection is needed.
- Level B: Should be worn when the highest level of respiratory protection is needed, but a lesser degree of skin protection is needed.
- Level C: Should be worn when a lesser level of respiratory protection is needed than Level B. Skin protection criteria are similar to Level B.
- Level D: Should be worn only as a work uniform and not on any site with respiratory or skin hazards. It provides no protection against chemical hazards.

The Level of Protection selected should be based on the hazard and risk of exposure.

Hazard:	Type and measured concentration of the chemical substance in the ambient atmosphere and its toxicity.
Risk:	Potential for exposure to substances in air, splashes of liquids, or other direct contact with material due to work being done.

In situations where the type of chemical, concentration, and possibilities of contact are not known, the appropriate Level of Protection must be selected based on professional experience and judgment until the hazards can be better characterized.

Personnel protective equipment reduces the potential for contact with toxic substances. Additionally, safe work practices, decontamination, site entry protocols, and other safety procedures further ensure the health and safety of responders. Together, these provide an integrated approach for reducing harm to response personnel.

III. LEVELS OF PROTECTION

A. Level A Protection

1. Personnel protective equipment

- Pressure-demand, supplied-air respirator approved by the Mine Safety and Health Administration (MSHA) and National Institute for Occupational Safety and Health (NIOSH). Respirators may be:
    - -- pressure-demand, self-contained breathing apparatus (SCBA), or
    - -- pressure-demand, airline respirator (with an escape bottle for atmospheres with, or having the potential for, Immediately Dangerous to Life and Health (IDLH) contaminant concentrations).
- Fully encapsulating chemical-resistant suit
- Coveralls*, or
- Long cotton underwear*
- Gloves (inner), chemical-resistant
- Boots, chemical-resistant, steel toe and shank. (Depending on suit construction, worn over or under suit boot)
- Hard hat* (under suit)*
- Disposable gloves and boot covers* (Worn over fully encapsulating suit)

- Cooling unit*
- 2-Way radio communications (inherently safe)

(*) optional

2. Criteria for selection

Meeting any of these criteria warrants use of Level A Protection:

- The chemical substance has been identified and requires the highest level of protection for skin, eyes, and the respiratory system.
- Substances with a high degree of hazard to the skin are suspected to be present, and skin contact is possible. Skin contact includes: splash, immersion, or contamination from atmospheric vapors, gases, or particulates.
- Operations must be conducted in confined, poorly ventilated areas until the absence of substances requiring Level A protection is determined.
- Direct readings on field Flame Ionization Detectors (FID) or Photoionization Detectors (PID) and similar instruments indicate high levels of unidentified vapors and gases in the air. (See Appendixes I and II.)

3. Guidance on selection

a. Fully encapsulating suits are primarily designed to provide a gas or vapor tight barrier between the wearer and atmospheric contaminants. Therefore, Level A is generally worn when high concentrations of airborne substances that could severely effect the skin are known or presumed to be present. Since Level A requires the use of a self-contained breathing apparatus more protection is afforded to the eyes and respiratory system.

Until air surveillance data are available to assist in the selection of the appropriate

Level of Protection, the use of Level A may have to be based on indirect evidence of the potential for atmospheric contamination or other means of skin contact with substances having severe skin affecting properties.

Conditions that may require Level A protection include:

- Confined spaces: Enclosed, confined, or poorly ventilated areas are conducive to build up of toxic vapors, gases, or particulates. An entry into an enclosed space does not automatically warrant Level A protection, but should serve as a cue to carefully consider the justification for a lower Level of Protection.

- Suspected or known highly toxic substances: Various substances that are highly toxic, especially through skin absorption, require Level A. Technical grade pesticides, concentrated phenolic compounds, Poison "A" compounds, fuming corrosives, and a wide variety of organic solvents are of this type. Carcinogens, and infectious substances known or suspected to be involved may require Level A protection. Field instruments may not be available to detect or quantify air concentrations of these materials. Until these substances are identified and their concentrations determined, maximum protection is necessary.

- Visible indicators: Visible air emissions from leaking containers or railroad or truck tank cars, as well as smoke from chemical fires and others, indicate high potential for concentrations of substances that could be extreme respiratory or skin hazards.

- Job functions: Initial site entries are generally walk-throughs in which instruments and visual observations are used to make a preliminary evaluation of the hazards.

In initial site entries, Level A should be worn when:

- -- there is a probability for exposure to high concentrations of vapors, gases, or particulates.
- -- substances are known or suspected of being extremely toxic directly to the skin or by being absorbed.

Subsequent entries are to conduct the many activities needed to reduce the environmental impact of the incident. Levels of Protection for later operations are based not only on data obtained from the initial and subsequent environmental monitoring, but also on the protective properties of suit material as well. The probability of contamination and ease of decontamination must also be considered.

Examples of situations where Level A has been worn are:

- Excavating soil to sample buried drums suspected of containing high concentrations of dioxin.
- Entering a cloud of chlorine to repair a valve broken in a railroad accident.
- Handling and moving drums known to contain oleum.
- Responding to accidents involving cyanide, arsenic, and undiluted pesticides.

b. The fully encapsulating suit provides the highest degree of protection to skin, eyes, and respiratory system given that the suit material resists chemicals during the time the suit is worn. While Level A provides maximum protection, all suit materials may be rapidly permeated and degraded by certain chemicals. These limitations should be recognized when specifying the type of fully encapsulating suit. Whenever possible, the suit material should be matched with the substance it is used to protect against.

B. Level B Protection

1. Personnel protective equipment

   - Pressure-demand, supplied-air respirator (MSHA/NIOSH approved). Respirators may be:
     - -- pressure-demand, self-contained breathing apparatus, or
     - -- pressure-demand, airline respirator (with escape bottle for IDLH or potential for IDLH atmosphere)
   - Chemical-resistant clothing (includes: overalls and long-sleeved jacket or hooded, one or two-piece chemical-splash suit or disposable chemical-resistant, one-piece suits)
   - Long cotton underwear*, or
   - Coveralls*
   - Gloves (outer), chemical-resistant
   - Gloves (inner), chemical-resistant
   - Boots (outer), chemical-resistant, steel toe and shank
   - Boot covers (outer), chemical-resistant (disposable)*
   - Hard hat (face shield*)
   - 2-Way radio communications (inherently safe)

   (*) optional

2. Criteria for selection

   Meeting any one of these criteria warrants use of Level B protection:

- The type and atmospheric concentration of toxic substances has been identified and requires a high level of respiratory protection, but less skin protection than Level A. These would be:
    - Atmospheres with IDLH concentrations, but the substance or its concentration in air does not represent a severe skin hazard, or
    - Chemicals or concentrations involved do not meet the selection criteria permitting the use of air-purifying respirators.
- The atmosphere contains less than 19.5% oxygen.
- It is highly unlikely that the work being done will generate high concentrations of vapors, gases or particulates, or splashes of material that will affect the skin.
- Atmospheric concentrations of unidentified vapors or gases are indicated by direct readings on instruments such as the FID or PID or similar instruments, but vapors and gases are not suspected of containing concentrations of skin toxicants. (See Appendixes I and II.)

3. Guidance on selection

a. Level B does not afford the maximum skin (and eye) protection as does a fully encapsulating suit since the chemical-resistant clothing is not considered gas, vapor, or particulate tight. However, a good quality, hooded, chemical-resistant, one-piece garment, with taped wrist, ankles, and hood does provides a reasonable degree of protection against splashes of liquids and lower concentrations of chemicals in the ambient air.

At most abandoned, outdoor hazardous waste sites, ambient atmospheric gas or vapor levels usually do approach concentrations sufficiently high to warrant Level A protection. In all but a few circumstances, Level B should provide the protection needed for initial reconnaissance.

Subsequent operations require a re-evaluation of Level B protection based on the probability of being splashed by chemicals, their effect on the skin, or the presence of hard-to-detect air contaminants. The generation of highly toxic gases, vapors, or particulates, due to the work being done must also be considered.

b. The chemical-resistant clothing required in Level B is available in a wide variety of styles, materials, construction detail, and permeability. One or two-piece garments are available with or without hoods. Disposable suits with a variety of fabrics and design characteristics are also available. Taping joints between the gloves, boots and suit, and between hood and respirator reduces the possibility for splash and vapor or gas penetration, but is not a gas tight barrier.

These factors and other selection criteria all affect the degree of protection afforded. Therefore, a specialist should select the most effective chemical-resistant clothing based on the known or anticipated hazards and job function.

Level B equipment does provides a high level of protection to the respiratory tract. Generally, if a self-contained breathing apparatus is required, selecting chemical-resistant clothing (Level B) rather than a fully encapsulating suit (Level A) is based on the need for less protection against known or anticipated substances affecting the skin. Level B skin protection is selected by:

- Comparing the concentrations of known or identified substances in air with skin toxicity data.
- Determining the presence of substances that are destructive to or readily absorbed through the skin by liquid splashes, unexpected high levels of gases, vapor, or particulates, or by other means of direct contact.
- Assessing the effect of the substance (at its measured air concentrations or

potential for splashing) on the small areas left unprotected by chemical-resistant clothing. A hooded garment, taped to the mask with boots and gloves taped to the suit, further reduces the area for potential skin exposure.

c. For initial site entry and reconnaissance at an open site, approaching whenever possible from upwind, Level B protection (with good quality, hooded, chemical-resistant clothing) should protect response personnel, providing the conditions described in selecting Level A are known or judged to be absent.

C. Level C Protection

1. Personnel protective equipment

- Air-purifying respirator, full-face, canister-equipped (MSHA/NIOSH approved)
- Chemical-resistant clothing (includes: coveralls or hooded, one-piece or two-piece chemical splash suit or chemical-resistant hood and apron; disposable chemical-resistant coveralls)
- Coveralls*, or
- Long cotton underwear*
- Gloves (outer), chemical-resistant
- Gloves (inner), chemical-resistant
- Boots (outer), chemical-resistant, steel toe and shank
- Boot covers (outer), chemical-resistant (disposable)*
- Hard hat (face shield*)
- Escape mask*
- 2-Way radio communications (inherently safe)

(*) optional

2. Criteria for selection

Meeting all of these criteria permits use of Level C protection:

- Oxygen concentrations are not less than 19.5% by volume.
- Measured air concentrations of identified substances will be reduced by the respirator below the substance's threshold limit value (TLV) and the concentration is within the service limit of the canister.
- Atmospheric contaminant concentrations do not exceed IDLH levels.
- Atmospheric contaminants, liquid splashes, or other direct contact will not adversely affect any body area left unprotected by chemical-resistant clothing.
- Job functions do not require self-contained breathing apparatus.
- Direct readings are a few ppms above background on instruments such as the FID or PID. (See Appendices I and II.)

3. Guidance on selection

a. Level C protection is distinguished from Level B by the equipment used to protect the respiratory system, assuming the same type of chemical-resistant clothing is used. The main selection criterion for Level C is that atmospheric concentrations and other selection criteria permit wearing air-purifying respirators.

The air-purifying device must be a full-face respirator (MSHA/NIOSH approved) equipped with a canister suspended from the chin or on a harness. Canisters must be able to remove the substances encountered. Half-masks or cheek cartridge equipped, full-face masks should be used only with the approval of a qualified health and safety professional.

In addition, a full-face, air-purifying mask can be used only if:

- Substance has adequate warning properties.
- Individual passes a qualitative fit-test for the mask.
- Appropriate cartridge/canister is used, and its service limit concentration is not exceeded.
- Site operations are not likely to generate unknown compounds or excessive concentrations of already identified substances.

b. An air surveillance program is part of all response operations when atmospheric contamination is known or suspected. It is particularly important that the air be thoroughly monitored when personnel are wearing air-purifying respirators. Periodic surveillance using direct-reading instruments and air sampling is needed to detect any changes in air quality necessitating a higher level of respiratory protection.

c. Level C protection with a full-face, air-purifying respirator should be worn routinely in an atmosphere only after the type of air contaminant is identified, concentrations measured and the criteria for wearing air-purifying respirator met. A decision on continuous wearing of Level C must be made after assessing all safety considerations, including:

    - The presence of (or potential for) organic or inorganic vapors or gases against which a canister is ineffective or has a short service life.
    - The known (or suspected) presence in air of substances with low TLVs or IDLH levels.

- The presence of particulates in air.
- The errors associated with both the instruments and monitoring procedures used.
- The presence of (or potential for) substances in air which do not elicit a response on the instrument used.
- The potential for higher concentrations in the ambient atmosphere or in the air adjacent to specific site operations.

d. The continuous use of air-purifying respirators (Level C) must be based on the identification of the substances contributing to the total vapor or gas concentration and the application of published criteria for the routine use of air-purifying devices. Unidentified ambient concentrations of organic vapors or gases in air approaching or exceeding a few ppm above background require, as a minimum, Level B protection.

D. Level D Protection

1. Personnel protective equipment

    - Coveralls
    - Gloves*
    - Boots/shoes, leather or chemical-resistant, steel toe and shank
    - Safety glasses or chemical splash goggles*
    - Hard hat (face shield*)
    - Escape mask*

2. Criteria for selection

Meeting any of these criteria allows use of Level D protection:

- No contaminants are present.
- Work functions preclude splashes, immersion, or potential for unexpected inhalation of any chemicals.

Level D protection is primarily a work uniform. It can be worn only in areas where there is no possibility of contact with contamination.

III. PROTECTION IN UNKNOWN ENVIRONMENTS

In all incident response, selecting the appropriate personnel protective equipment is one of the first steps in reducing health effects from toxic substances. Until the toxic hazards at an incident can be identified and personnel safety measures commensurate with the hazards instituted, preliminary safety requirements must be based on experience, judgment, and professional knowledge.

Of primary concern in evaluating unknown situations are atmospheric hazards. Toxic concentrations (or potential concentrations) of vapors, gases, and particulates; low oxygen content; explosive potential; and the possibility of radiation exposure all represent immediate atmospheric hazards. In addition to making air measurements to determine these hazards, visual observation and review of existing data can help determine the potential risks from other materials.

Once immediate hazards, other than toxic substances have been eliminated, the initial on-site survey and reconnaissance continues. Its purpose is to further characterize toxic hazards and, based on these findings, refine preliminary safety requirements. As data is obtained from the initial survey, the Level of Protection and other safety procedures are adjusted. Initial data also provide information upon which to base further monitoring and sampling requirements. No one method can determine a Level of Protection in all unknown environments. Each situation must be examined individually.

IV. ADDITIONAL CONSIDERATIONS FOR SELECTING LEVELS OF PROTECTION

Other factors which should be considered in selecting the appropriate Level of Protection are:

A. Heat and Physical Stress

The use of protective clothing and respirators increases physical stress, in particular, heat stress on the wearer. Chemical protective clothing greatly reduces natural ventilation and diminishes the body's ability to regulate its temperature. Even in moderate ambient temperatures, the diminished capacity of the body to dissipate heat can result in one or more heat-related problems.

All chemical protective garments can be a contributing factor to heat stress. Greater susceptibility to heat stress occurs when protective clothing requires the use of a tightly fitted hood against the respirator face piece, or when gloves or boots are taped to the suit. As more body area is covered, less cooling takes place, increasing the probability of heat stress. Whenever any chemical-protective clothing is worn, a heat stress recovery monitoring program must occur. (See Part 7, Stress).

Wearing protective equipment also increases the risk of accidents. It is heavy, cumbersome, decreases dexterity, agility, interferes with vision, and is fatiguing to wear. These factors all increase physical stress and the potential for accidents. In particular, the necessity of selecting Level A protection should be balanced against the increased probability of heat stress and accidents. Level B and C protection somewhat reduces accident probability because the equipment is lighter, less cumbersome, and vision problems are less serious.

B. Air Surveillance

A program must be established for routine, periodic air surveillance. Without an air surveillance program, any atmospheric changes could go undetected and jeopardize response personnel. Surveillance can be accomplished with various types of air pumps and filtering devices followed by analysis of the filtering media; portable real-time monitoring instruments located strategically on-site; personal dosimeters; and periodic walk-through by personnel carrying direct-reading instruments. (See Part 10, Air Surveillance).

C. Decision-Logic for Selecting Protective Clothing

No adequate criteria, similar to the respiratory protection decision-logic, are available for selecting protective clothing. A concentration of a known substance in the air approaching a TLV or permissible exposure limit for the skin does not automatically warrant a fully encapsulating suit. A hooded, high quality, chemical-resistant suit may provide adequate protection. The selection of Level A over Level B is a judgment that should be made by a qualified individual considering the hazards and risk.

Hazards: The physical form of the potential contaminant must be considered. Airborne substances are more likely to contact personnel wearing non-encapsulating suits, which are not considered gas or vapor tight. Liquids contacting the skin are generally considered more hazardous than contact with vapors, gases and particulates.

Effect of the contaminant on skin:

- highly hazardous substances are those that are easily absorbed through the skin causing systemic effects, or that cause severe skin destruction.
- less hazardous substances are those that are not easily absorbed through the skin causing systemic effects, or that do not cause severe skin destruction

Risk: Concentration of the contaminant: The higher the concentration, the higher the probability of injury.

Work function: Site work activities dictate the probability of direct and indirect skin contact.

Instability of the situation: A higher Level of Protection should be considered when there is a probability of a release involving vapor or gases, splashes or immersion in liquids, or through the loss of container integrity.

D. Atmospheric Conditions

Atmospheric conditions such as stability, temperature, wind direction and wind velocity, as well as barometric pressure determine the behavior of contaminants in air or the potential for volatile material being released into the air. These parameters should be considered when determining the need for and Level of Protection required.

E. Work in the Exclusion Zone

For operations in the Exclusion Zone (area of potential contamination), different Levels of Protection may be selected, and various types of chemical-resistant clothing worn. This selection would be based on measured air concentrations, the job function, the potential for skin contact or inhalation of the materials present, and ability to decontaminate the protective equipment used. (See Part 8, Site Control - Work Zones).

G. Escape Masks

Carrying an escape, self-contained breathing apparatus of at least five minute duration, is optional in while wearing Level C or Level D protection. For initial site entry, a specialist should determine, on-a-case-by basis, whether they should be carried, or be strategically located in areas that have higher possibilities for harmful exposure.

V. VAPOR OR GAS CONCENTRATIONS AS INDICATED BY DIRECT-READING INSTRUMENTS

Instruments such as the FID and PID can be used to detect the presence of many organic vapors or gases either as single compounds or mixtures. Dial readings are frequently referred to, especially with unidentified substances, as total vapor and gas concentrations (in ppm). More correctly, they are deflections of the needle on the dial indicating an instrument response and do not directly relate to the total concentration in the air. As a guide to selecting Levels of Protection, based on dial readings, the following values could be used. They must not be used as the sole criteria for selecting Levels of Protection.

PART 7

STRESS

I. INTRODUCTION

Both physiological and psychological stress effect response personnel. Working in adverse weather conditions, wearing chemical protective clothing, close proximity to hazardous materials, and for some emergency responders working in life-threatening situations, all contribute to physical strain and possibly mental anxiety. Under certain conditions, stress significantly contributes to worker accidents and illnesses. To reduce the potential for abnormal physical stress or mental anxiety:

- Workers must be periodically examined by a physician to determine if they are physically and psychologically fit to perform their jobs.

- Continual practice and training must be provided in using personnel protective equipment (especially self-contained breathing apparatus and chemical-resistant protective clothing).

- An effective safety program must be established and a dedicated effort made to protect the worker. These actions will help assure personnel that their health and safety will be protected now and in the future.

II. WEATHER

Adverse weather conditions are important considerations in planning and conducting site operations. Hot or cold weather can cause physical discomfort, loss of efficiency, and personal injury. Of particular importance is heat stress resulting from protective clothing decreasing natural ventilation of the body. Heat stress can occur even when temperatures are considered moderate. One or more of the following recommendations will help reduce heat stress:

- Provide plenty of liquids. To replace body fluids (water and electrolytes) lost due to sweating, drink plenty of water, commercial drink mixes along with more heavily salted foods (unless on a low salt diet). To prevent dehydration, response personnel should be encouraged to drink generous amounts of water even if not thirsty.

Heat-related problems can happen before the sensation of thirst occurs.

- Provide cooling devices to aid natural body ventilation. These devices, however, add weight, and their use should be balanced against worker fatigue. Long cotton underwear or similar type garments act as a wick to help absorb moisture and protect the skin from direct contact with heat-absorbing chemical protective clothing. It should be the minimum undergarment worn.

- Install mobile showers and/or hose-down facilities to reduce body temperature and cool protective clothing.

- Ensure that adequate shelter is available to protect personnel against heat, cold, rain, snow, and that a shaded resting area is provided on sunny days. On hot days, air conditioned rest areas should be provided.

- In hot weather, rotate teams of workers wearing protective clothing or performing extremely arduous tasks. In extremely hot weather, conduct non-emergency response operations in the early morning or evening.

- Response personnel should be encouraged to maintain their physical fitness. Physically fit personnel are less prone to stress-related problems.

- Liquids which act as diuretics (such as alcohol and coffee) should be avoided or their intake minimized prior to anticipated operations. These can contribute to dehydration and subsequent heat-related problems.

III. HEAT STRESS MONITORING

For monitoring the body's recuperative ability to handle excess heat, one or more of the following techniques should be used as a screening technique. Monitoring of personnel wearing protective clothing should commence when the ambient temperature is 70 degrees Fahrenheit or above. Frequency of monitoring should increase as the ambient temperature increases or if slow recovery rates are indicated. When temperatures exceed 80 degrees Fahrenheit workers must be monitored for heat stress after every work period.

- Heart rate (HR) should be measured by counting the radial pulse for 30 seconds as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 110 beats per minute. If the HR is higher, the next work period should be shortened by 10 minutes (or 33%), while the length of the rest period stays the same. If the pulse rate is 100 beats per minute at the beginning of the next rest period, the following work cycle should be shortened by 33%.

- Body temperature should be measured orally with a clinical thermometer as early as possible in the resting period. Oral temperature (OT) at the beginning of the rest period should not exceed 99 degrees Fahrenheit. If it does, the next work period should be shortened by 10 minutes (or 33%), while the length of the rest period stays the same. However, if the OT exceeds 99.7 degrees Fahrenheit at the beginning of the next period, the following work cycle should be further shortened by 33%. OT should be measured again at the end of the rest period to make sure that it has dropped below 99 degrees Fahrenheit.

- Body water loss (BWL) due to sweating should be measured by weighing the worker in the morning and in the evening. The clothing worn should be similar at both weighings; preferably the worker should be nude. The scale should be accurate to plus or minus 1/4 lb. BWL should not exceed 1.5% of the total body weight. If it does, workers should be instructed to increase their daily intake of fluids to replace the water lost through perpiration. Ideally, body fluids should be maintained at a constant level during the work day. This requires replacement of salt lost in sweat as well.

Good hygienic standards must be maintained by frequent change of clothing and daily showering. Clothing should be permitted to dry during rest periods. Persons who notice skin problems should immediately consult medical personnel.

IV. EFFECTS OF HEAT STRESS

If the body's physiological processes fail to maintain a normal body temperature because of excessive heat, a number of physical reactions can occur ranging from mild (such as fatigue, irritability, anxiety, and decreased concentration, dexterity, or movement) to fatal. Standard reference books should be consulted for specific first aid treatment. Medical help must be obtained for the more serious conditions.

Heat-related problems are:

- Heat rash: caused by continuous exposure to heat and humid air and aggravated by chafing clothes. Decreases ability to tolerate heat as well as being a nuisance.
- Heat cramps: caused by profuse perspiration with inadequate fluid intake and chemical replacement (especially salts). Signs: muscle spasm and pain in the extremities and abdomen.
- Heat exhaustion: caused by increased stress on various organs to meet increased demands to cool the body. Signs: shallow breathing; pale, cool, moist skin; profuse sweating; dizziness and lassitude.
- Heat stroke: the most severe form of heat stress. Can be fatal. Medical help must be obtained immediately. Body must be cooled immediately to prevent severe injury and/or death. Signs: red, hot, dry skin; no perspiration; nausea; dizziness and confusion; strong, rapid pulse; coma.

V. EFFECTS OF COLD EXPOSURE

Persons working outdoors in temperatures at or below freezing may be frostbitten. Extreme cold for a short time may cause severe injury to exposed body surfaces, or result in profound generalized cooling, causing death. Areas of the body which have high surface area-to-volume ratio such as fingers, toes, and ears, are the most susceptible.

Two factors influence the development of a cold weather injury: ambient temperature and the velocity of the wind. Wind chill is used to describe the chilling effect of moving air in combination with low temperature. For instance, 10 degrees Fahrenheit with a wind of 15 miles per hour (mph) is equivalent in chilling effect to still air at -18 degrees Fahrenheit.

As a general rule, the greatest incremental increase in wind chill occurs when a wind of 5 mph increases to 10 mph. Additionally, water conducts heat 240 times faster than air. Thus, the body cools suddenly when chemical-protective equipment is removed if the clothing underneath is perspiration soaked.

Local injury resulting from cold is included in the generic term frostbite. There are several degrees of damage. Frostbite of the extremities can be categorized into:

- Frost nip or incipient frostbite: characterized by suddenly blanching or whitening of skin.
- Superficial frostbite: skin has a waxy or white appearance and is firm to the touch, but tissue beneath is resilient.
- Deep Frostbite: tissues are cold, pale, and solid; extremely serious injury.

Systemic hypothermia is caused by exposure to freezing or rapidly dropping temperature. It can be fatal. Its symptoms are usually exhibited in five stages: 1) shivering, 2) apathy, listlessness, sleepiness, and (sometimes) rapid cooling of the body to less than 95 degrees Fahrenheit, 3) unconsciousness, glassy stare, slow pulse, and slow respiratory rate, 4) freezing of the extremities, and finally, 5) death.

Standard reference books should be consulted for specific first aids treatments. Medical help must be obtained for the more serious conditions.

VI. SUMMARY

Physiological and psychological stress can effect response personnel. These stresses occur in a number of ways. Persons responsible for health and safety programs must be aware that response personnel may be working under conditions that are conducive in causing stressful situations and make every effort to minimize the problems.

PART 8

SITE CONTROL - WORK ZONES

I. INTRODUCTION

The activities required during responses to incidents involving hazardous substances may contribute to the unwanted movement of contaminants from the site to uncontaminated areas. Response personnel and equipment may become contaminated and transfer the material into clean areas. Material may become airborne due to its volatility or to the disturbance of contaminated soil causing it to become wind-blown. To minimize the transfer of hazardous substances from the site, contamination control procedures are needed. Two general methods are used: establishing site work zones and removing contaminants from people and equipment.

II. CONTROL AT THE SITE

A site must be controlled to reduce the possibility of: 1) contact with any contaminants present, and 2) removal of contaminants by personnel or equipment leaving the site. The possibility of exposure or translocation of substances can be reduced or eliminated in a number of ways, including:

- Setting up site security to exclude unnecessary personnel from the general area.
- Minimizing the number of personnel and equipment on-site consistent with effective operations.
- Establishing work zones within the site.
- Establishing control points to regulate access to work zones.
- Conducting operations in a manner to reduce the exposure of personnel and equipment and to eliminate the potential for airborne dispersion.
- Implementing decontamination procedures.

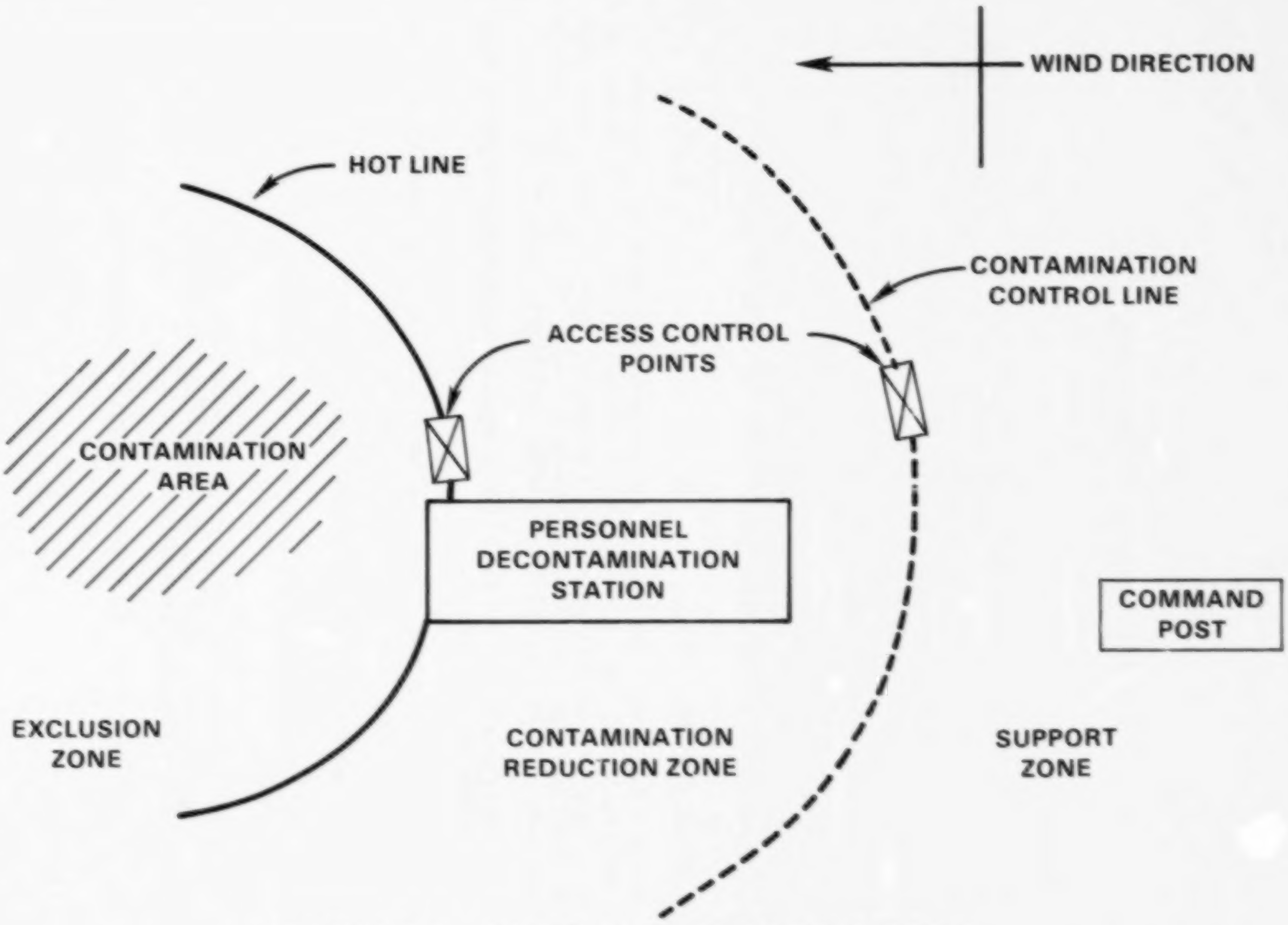

WIND DIRECTION
HOT LINE
CONTAMINATION
CONTROL LINE
ACCESS CONTROL
POINTS
CONTAMINATION
AREA
PERSONNEL
DECONTAMINATION
STATION
COMMAND
POST
EXCLUSION
ZONE
CONTAMINATION
REDUCTION ZONE
SUPPORT
ZONE

FIGURE 8-1 DIAGRAM OF SITE WORK ZONES

III. WORK ZONES

One method of preventing or reducing the migration of contaminants is to delineate zones on the site in which prescribed operations occur. Movement of personnel and equipment between zones and onto the site itself would be limited by access control points. Three contiguous zones (Figure 8-1) are recommended:

Zone 1: Exclusion Zone

Zone 2: Contamination Reduction Zone

Zone 3: Support Zone

A. Zone 1: Exclusion Zone

The Exclusion Zone, the innermost of three areas, is the physical area where contamination does or could occur. All people entering the Exclusion Zone must wear prescribed Levels of Protection. Entry and exit check points must be established at the periphery of the Exclusion Zone to regulate the flow of personnel and equipment into and out of the zone and to verify that the procedures established to enter and exit are followed.

The outer boundary of Zone 1, the Hotline, is initially established by visually surveying the immediate vicinity of the incident and determining where the hazardous substances involved are located; where any drainage, leachate, or spilled material is; and whether any discolorations are visible. Guidance in determining the boundaries is also provided by data from the initial site survey indicating the presence of organic or inorganic vapors/gases or particulates in air, combustible gases, and radiation, or the results of water and soil sampling.

Additional factors that should be considered include the distances needed to prevent fire or an explosion from affecting personnel outside the zone, the physical area necessary to conduct site operations, and the potential for contaminants to be blown from the area. Once the Hotline has been determined it should be physically secured, fenced, or well-defined by landmarks. During subsequent site operations, the boundary may be modified and adjusted as more information becomes available.

B. Subareas Within the Exclusion Zone

All personnel within the Exclusion Zone must wear the required Level of Protection. Personnel protective equipment is designated based on site-specific conditions and the hazards that might be encountered. Frequently within the Exclusion Zone, different Levels of Protection are justified. Subareas are specified and conspicuously marked as to whether Level A, B, or C protection is required (Figure 8-2). The Level of Protection is determined by the measured concentration of substances in air, potential for contamination, and the known or suspected presence of toxic substances.

The job assignment or the type of work to be done might also dictate the Levels of Protection to be worn. For example, collecting samples from open containers might require Level B protection, while for walk-through ambient air monitoring, Level C protection might be sufficient. The assignment, when appropriate of different Levels of Protection within the Exclusion Zone generally makes for a more flexible, effective, and less costly operation while still maintaining a high degree of safety.

C. Zone 3: Support Zone

The Support Zone, the outermost part of the site, is considered a non-contaminated or clean area. Support equipment (command post, equipment trailer, etc.) is located in the zone; traffic is restricted to authorized response personnel. Since normal work clothes are appropriate within this zone, potentially contaminated personnel clothing, equipment, and samples are not permitted, but are left in the Contamination Reduction Zone until they are decontaminated.

The location of the command post and other support facilities in the Support Zone depends on a number of factors, including:

- Accessibility: topography; open space available; location of highways; railroad tracks; or other limitations.
- Wind Direction: Preferably the support facilities should be located upwind of the exclusion Zone. However, shifts in the wind and other conditions may be such that an ideal location based on wind direction alone does not exist.

- Resources: Adequate roads, power lines, water, and shelter should be available in close proximity to the site.

D. Zone 2: Contamination Reduction Zone

Between the Exclusion Zone and the Support Zone is the Contamination Reduction Zone which provides a transition between contaminated and clean zones. Zone 2 serves as a buffer to further reduce the probability of the clean zone becoming contaminated or being affected by other existing hazards. It provides additional assurance that the physical transfer of contaminated substances on people, equipment, or in the air is limited through a combination of decontamination, distance between the Exclusion and Support Zones, air dilution, zone restrictions, and work functions.

Initially, the Contamination Reduction Zone is considered a non-contaminated area. At the boundary between the Exclusion and Contamination Reduction Zones, Contamination Reduction Corridors (consisting of an appropriate number of decontamination stations) are established, one for personnel and one for heavy equipment. Depending on the size of the operation, more than two corridors may be necessary. Exit from the Exclusion Zone is through a Contamination Reduction Corridor. As operations proceed, the area around the contamination station may become contaminated, but to a much lesser degree than the Exclusion Zone. On a relative basis, the amount of contaminants should decrease from the Hotline to the Support Zone due to the distance involved and the decontamination procedures used.

The boundary between the Support Zone and the Contamination Reduction Zone, the Contamination Control Line, separates the possibly low contamination area from the clean Support Zone. Access to the Contamination Reduction Zone from the Support Zone is through a control point. Personnel entering this zone should wear the prescribed personnel protective equipment, if required, for working in the Contamination Reduction Zone. Entering the Support Zone requires the removal of any protective equipment worn in the Contamination Reduction Zone.

IV. OTHER CONSIDERATIONS

A. The use of the three-zone system, access control points, and exacting decontamination procedures, provides a reasonable assurance against the translocation of contaminating substances. This site control system is based on a worst case situation. Less stringent site control and decontamination procedures may be utilized if more definitive information is available on the types of substances involved and the hazards they present. This information can be obtained through air monitoring, instrument survey and sampling, along with available technical information concerning the characteristics and behavior of the material present.

B. Area Dimensions

The distance between the Hotline, Contamination Control Line, and Command Post and the size and shape of each zone have to be based on conditions specific to each site (Figures 8-2 and 8-3). Considerable judgment is needed to assure that the distances between zone boundaries are large enough to allow room for the necessary operations, provide adequate distances to prevent the spread of contaminants, and eliminate the possibility of injury due to explosions or fires. Long-term operations would involve developing reasonable methods (for example, air surveillance, swipe testing, and visible deterioration) to determine if material is being transferred between zones and to assist in modifying site boundaries.

The following criteria should be considered in establishing area dimensions and boundaries:

- Physical and topographical features of the site.
- Weather conditions.
- Field/laboratory measurements of air contaminants and environmental samples.
- Air dispersion calculations.
- Physical, chemical, toxicological, and other characteristics of the substances present.
- Cleanup activities required.
- Potential for fire.

- size of area needed to conduct operations.
- Decontamination procedures.
- Potential for exposure.
- Proximity to residential or industrial areas.

C. Monitoring and Sampling

To verify that site control procedures are preventing the spread of contamination, a monitoring and sampling program should be established. The Support Zone should be periodically monitored for air contaminants using direct-reading instruments and by collecting air samples for particulate, gas or vapor analysis. Analysis of soil samples collected in the most heavily trafficked areas would indicate contaminants being carried from the Exclusion Zone by personnel, equipment, wind, or surface water runoff. Occasional swipe tests should be taken in trailers and other areas used by personnel.

These same types of samples should be collected and the air monitored in the Contamination Reduction Zone. Increased concentrations in air or other environmental media may indicate a breakdown in control over the Contamination Reduction Corridor, ineffective decontamination procedures, or failure to restrict site access.

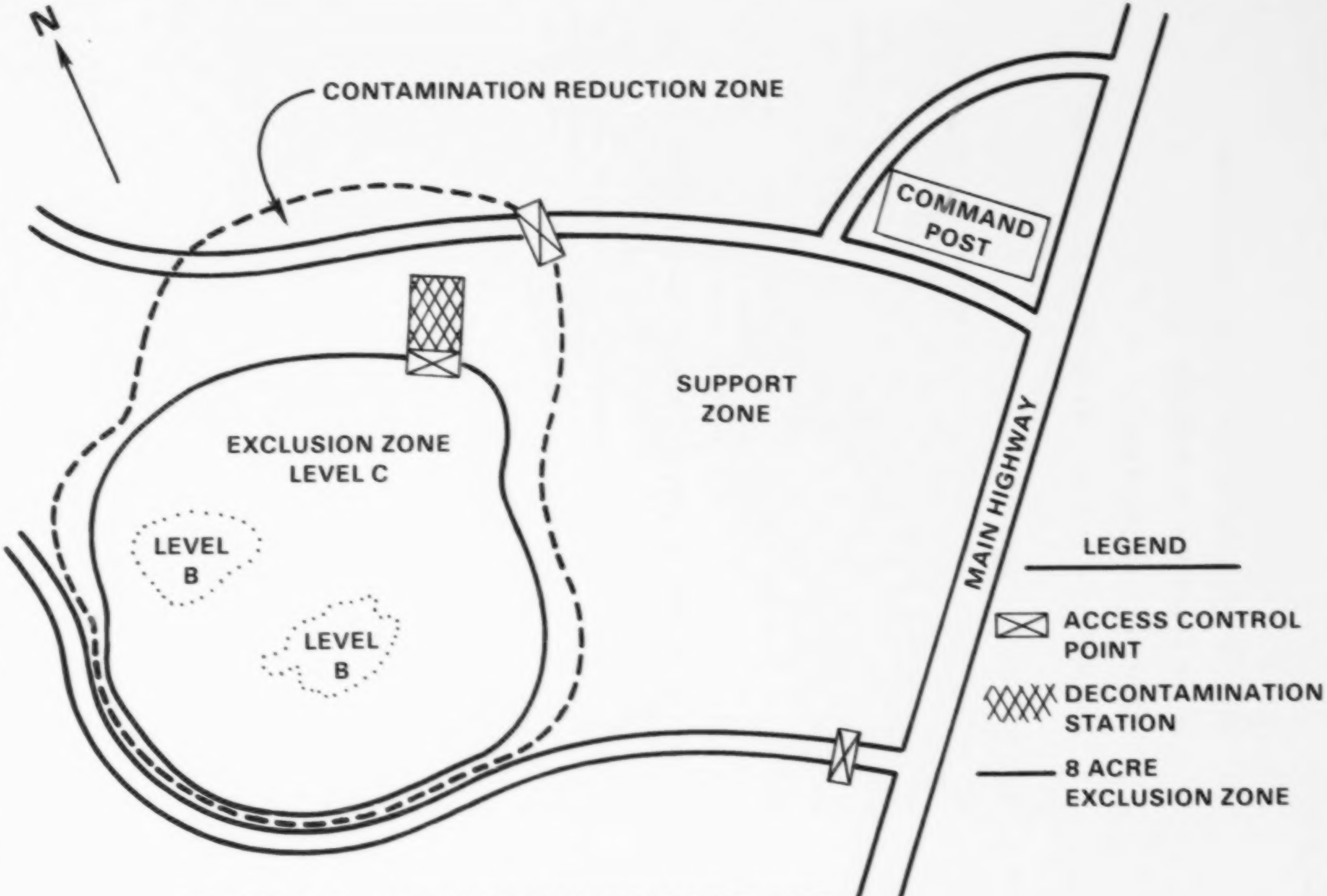

N
CONTAMINATION REDUCTION ZONE
COMMAND POST
SUPPORT ZONE
EXCLUSION ZONE LEVEL C
LEVEL B
LEVEL B
MAIN HIGHWAY
LEGEND
⊠ ACCESS CONTROL POINT
▩ DECONTAMINATION STATION
— 8 ACRE EXCLUSION ZONE

FIGURE 8-3 NEW HAMPSHIRE WASTE SITE

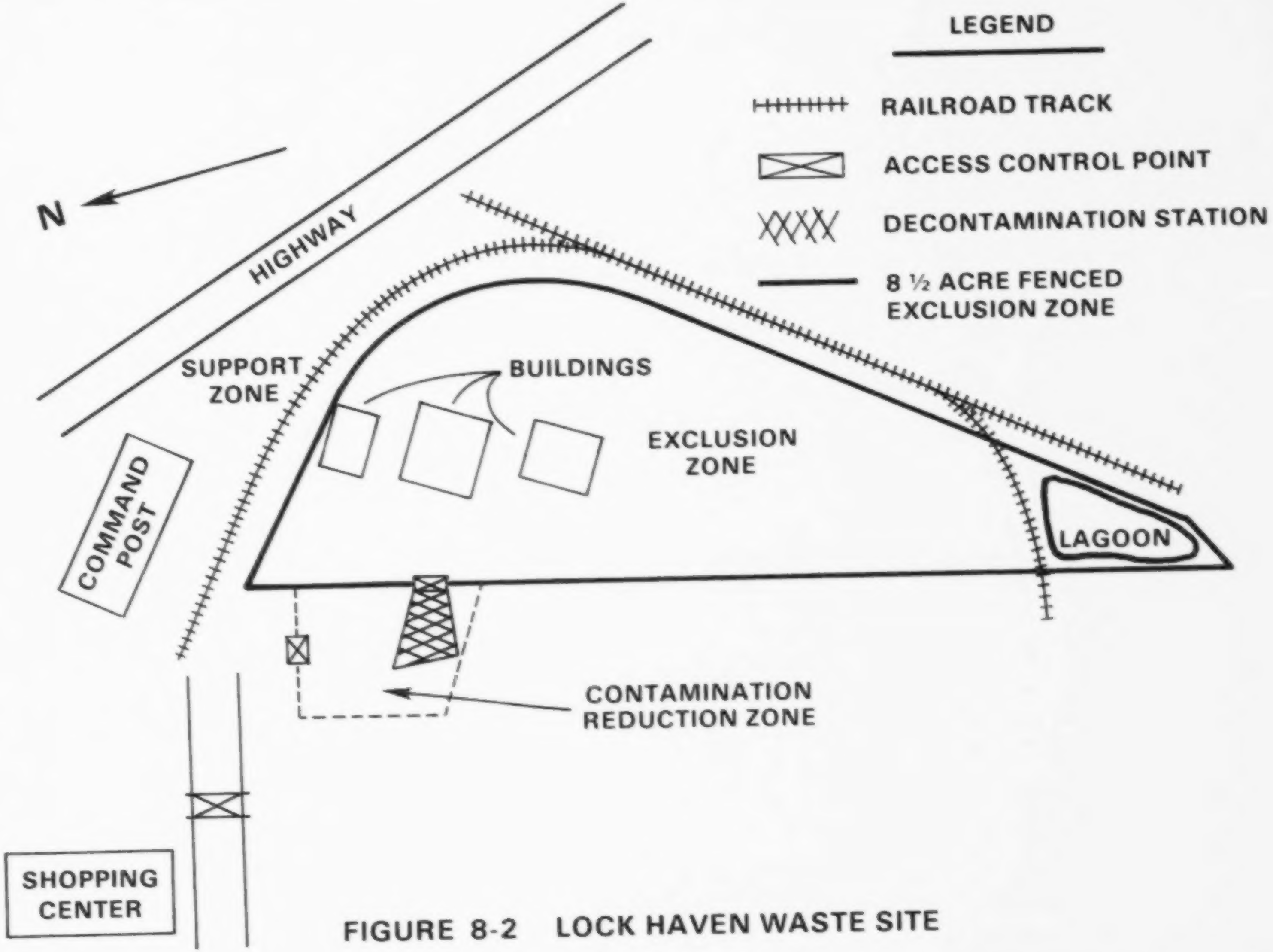

LEGEND
RAILROAD TRACK
ACCESS CONTROL POINT
DECONTAMINATION STATION
8 ½ ACRE FENCED EXCLUSION ZONE
N
HIGHWAY
SUPPORT ZONE
BUILDINGS
EXCLUSION ZONE
LAGOON
COMMAND POST
CONTAMINATION REDUCTION ZONE
SHOPPING CENTER

FIGURE 8-2 LOCK HAVEN WASTE SITE

EPA ENVIRONMENTAL RESPONSE TEAM

PART 9

SITE CONTROL - DECONTAMINATION

I. INTRODUCTION

Personnel responding to hazardous substance incidents may become contaminated in a number of ways including:

- Contacting vapors, gases, mists, or particulates in the air.

- Being splashed by materials while sampling or opening containers. Walking through puddles of liquids or sitting or kneeling on contaminated soil.

- Using contaminated instruments or equipment.

Protective clothing and respirators help prevent the wearer from becoming contaminated or inhaling contaminants. Good work practices help reduce contamination on protective clothing, instruments, and equipment.

Even with these safeguards, contamination may occur. Harmful materials can be transferred to clean areas, exposing unprotected personnel. During removal of contaminated clothing, personnel may contact contaminants on their clothing or inhale them. To prevent such occurrences, methods to reduce contamination, and decontamination procedures must be developed and established before anyone enters a site and must continue (modified when necessary) throughout site operations.

Decontamination consists of physically removing contaminants or changing their chemical nature to innocuous substances. How extensive decontamination must be depends on a number of factors, the most important being the type of contaminants involved. The more harmful the contaminant, the more extensive and thorough decontamination must be. Less harmful contaminants may require less decontamination.

Combining decontamination, the correct method of doffing personnel protective equipment, and the use of site work zones minimizes cross contamination from protective clothing to wearer, equipment to personnel, and from one area to another. Only general guidance can be given on methods and techniques for decontamination. The exact procedure to use must be determined after evaluating a number of factors specific to the incident.

II. PRELIMINARY CONSIDERATIONS

A. Initial Planning

The initial decontamination plan assumes all personnel and equipment leaving the Exclusion Zone (area of potential contamination) are grossly contaminated. A system is then set up for personnel decontamination to wash and rinse, at least once, all the protective equipment worn. This is done in combination with a sequential doffing of protective equipment, starting at the first station with the most heavily contaminated item and progressing to the last station with the least contaminated article. Each procedure requires a separate station.

The spread of contaminants during the washing/doffing process is further reduced by separating each decontamination station by a minimum of 3 feet. Ideally, contamination should decrease as a person moves from one station to another further along in the line.

While planning site operations, methods should be developed to prevent the contamination of people and equipment. For example, using remote sampling techniques, not opening containers by hand, bagging monitoring instruments, using drum grapplers, watering down dusty areas, and not walking through areas of obvious contamination would reduce the probability of becoming contaminated and require a less elaborate decontamination procedure.

The initial decontamination plan is based on a worst-case situation or assumes no information is available about the incident. Specific conditions at the site are then evaluated, including:

- Type of contaminant.
- The amount of contamination.
- Levels of protection required.
- Type of protective clothing worn.

- Type of equipment needed to accomplish the work task.

The initial decontamination plan is modified, eliminating unnecessary stations or otherwise adapting it to site conditions. For instance, the initial plan might require a complete wash and rinse of chemical protective garments. If disposable garments are worn, the wash/rinse step could be omitted. Wearing disposable boot covers and gloves could eliminate washing and rinsing these items and reduce the number of stations needed. Changes in the decontamination procedure must be noted in the Site Safety Plan.

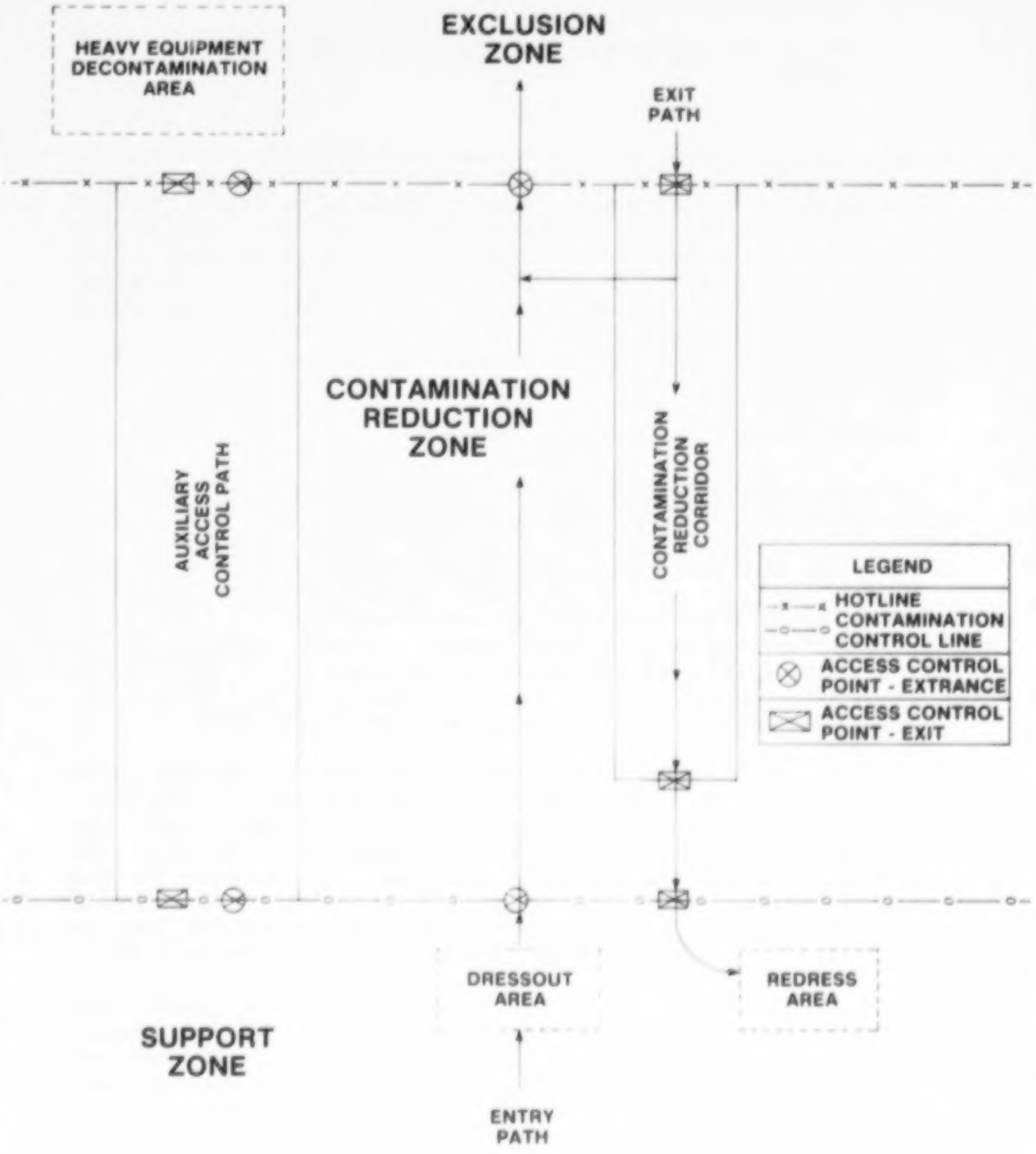
B. Contamination Reduction Corridor

An area within the Contamination Reduction Zone is designated the Contamination Reduction Corridor (CRC). The CRC controls access into and out of the Exclusion Zone and confines decontamination activities to a limited area. The size of the corridor depends on the number of stations in the decontamination procedure, overall dimensions of work control zones, and amount of space available at the site. A corridor of 75 feet by 15 feet is the minimum area for full decontamination. Whenever possible, it should be a straight path.

The CRC boundaries should be conspicuously marked, with entry and exit restricted. The far end is the hotline, the boundary between the Exclusion Zone and the Contamination Reduction Zone. Personnel exiting the Exclusion Zone must go through the CRC. Anyone in the CRC should be wearing the Level of Protection designated for the decontamination crew. Another corridor may be required for heavy equipment needing decontamination.

Within the CRC, distinct areas are set aside for decontamination of personnel, portable field equipment, removed clothing, etc. These areas should be marked and personnel restricted to those wearing the appropriate Level of Protection. All activities within the corridor are confined to decontamination.

Personnel protective clothing, respirators, monitoring equipment, and sampling supplies are all maintained outside of the CRC. Personnel don their protective equipment away from the CRC and enter the Exclusion Zone through a separate access control point at the hotline.


HEAVY EQUIPMENT DECONTAMINATION AREA
EXCLUSION ZONE
EXIT PATH
CONTAMINATION REDUCTION ZONE
AUXILIARY ACCESS CONTROL PATH
CONTAMINATION REDUCTION CORRIDOR
LEGEND
HOTLINE
CONTAMINATION CONTROL LINE
ACCESS CONTROL POINT - EXTRANCE
ACCESS CONTROL POINT - EXIT
DRESSOUT AREA
REDRESS AREA
SUPPORT ZONE
ENTRY PATH

CONTAMINATION REDUCTION ZONE LAYOUT

FIGURE 9-1

III. EXTENT OF DECONTAMINATION REQUIRED

A. Modifications of Initial Plan

The original decontamination plan must be adapted to specific conditions found at incidents. These conditions may require more or less personnel decontamination than planned, depending on a number of factors.

1. Type of Contaminant

The extent of personnel decontamination depends on the effects the contaminants have on the body. Contaminants do not exhibit the same degree of toxicity (or other hazard). Whenever it is known or suspected that personnel can become contaminated with highly toxic or skin-destructive substances, a full decontamination procedure should be followed. If less hazardous materials are involved, the procedure can be downgraded.

2. Amount of Contamination

The amount of contamination on protective clothing (and other objects or equipment) is usually determined visually. If, on visual examination, it appears grossly contaminated, a thorough decontamination is generally required. Gross material remaining on the protective clothing for any extended period of time may degrade or permeate it. This likelihood increases with higher air concentrations and greater amounts of liquid contamination. Gross contamination also increases the probability of personnel contact. Swipe tests may help determine the type and quantity of surface contaminants.

3. Level of Protection

The Level of Protection and specific pieces of clothing worn determine on a preliminary basis the layout of the decontamination line. Each Level of Protection incorporates different problems in decontamination and doffing of the equipment. For example: decontamination of the harness straps and backpack assembly of the self-contained breathing apparatus is difficult. A butyl rubber apron worn over the harness makes decontamination easier. Clothing variations and different Levels of

Protection may require adding or deleting stations in the original decontamination procedure.

4. Work Function

The work each person does determines the potential for contact with hazardous materials. In turn, this dictates the layout of the decontamination line. For example, observers, photographers, operators of air samplers, or others in the Exclusion Zone performing tasks that will not bring them in contact with contaminants may not need to have their garments washed and rinsed. Others in the Exclusion Zone with a potential for direct contact with the hazardous material will require more thorough decontamination. Different decontamination lines could be set up for different job functions, or certain stations in a line could be omitted for personnel performing certain tasks.

5. Location of Contamination

Contamination on the upper areas of protective clothing poses a greater risk to the worker because volatile compounds may generate a hazardous breathing concentration both for the worker and for the decontamination personnel. There is also an increased probability of contact with skin when doffing the upper part of clothing.

6. Reason for Leaving Site

The reason for leaving the Exclusion Zone also determines the need and extent of decontamination. A worker leaving the Exclusion Zone to pick up or drop off tools or instruments and immediately returning may not require decontamination. A worker leaving to get a new air cylinder or to change a respirator or canister, however, may require some degree of decontamination. Individuals departing the CRC for a break, lunch, or at the end of day, must be thoroughly decontaminated.

B. Effectiveness of Decontamination

There is no method to immediately determine how effective decontamination is. Discolorations, stains, corrosive effects, and substances adhering to objects may indicate contaminants have not been removed. However, observable effects only indicate surface contamination and not permeation (absorption) into clothing (tools or equipment). Also many contaminants are not easily observed.

A method for determining effectiveness of surface decontamination is swipe, or wipe testing. Cloth or paper patches - swipes - are wiped over predetermined surfaces of the suspect object and analyzed in a laboratory. Both the inner and outer surfaces of protective clothing should be swipe tested. Positive indications of both sets of swipes would indicate surface contamination has not been removed and substances have penetrated or permeated through the garment. Determining permeation of contaminants into protective garments requires laboratory analysis of a piece of the material. Both swipe and permeation testing provide after-the-fact information. Along with visual observations, results of these tests can help evaluate the effectiveness of decontamination.

In many cases, depending on the substances involved, chemical protective clothing (or naturally absorbable materials) may have to be discarded. If it cannot be determined that clothing or other items, for example, tools and equipment have been completely decontaminated, the only safe action is to consider them hazardous wastes and have them disposed of properly.

C. Equipment

Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations are ease of equipment decontamination or disposability. Most equipment and supplies can be easily procured. For example, soft-bristle scrub brushes or long-handle brushes are used to remove contaminants. Water in buckets or garden sprayers is used for rinsing. Large galvanized wash tubs or stock tanks can hold wash and rinse solutions. Children's wading pools can also be used. Large plastic garbage cans or other similar containers lined with plastic bags store contaminated clothing and equipment. Contaminated liquids can be stored temporarily in metal or plastic cans or drums. Other gear includes paper or cloth towels for drying protective clothing and equipment.

D. Decontamination Solution

Personnel protective equipment, sampling tools, and other equipment are usually decontaminated by scrubbing with detergent-water using a soft-bristle brush followed by rinsing with copious amounts of water. While this process may not be fully effective in removing some contaminants (or in a few cases, contaminants may react with water), it is a relatively safe option compared with using a chemical decontaminating solution. This requires that the contaminant be identified. A decon chemical is then needed that will change the contaminant into a less harmful substance. Especially troublesome are unknown substances or mixtures from a variety of known or unknown substances. The appropriate decontamination solution must be selected in consultation with an experienced chemist.

E. Establishment of Procedures

Once decontamination procedures have been established, all personnel requiring decontamination must be given precise instructions (and practice, if necessary). Compliance must be frequently checked. The time it takes for decontamination must be ascertained. Personnel wearing SCBAs must leave their work area with sufficient air to walk to CRC and go through decontamination.

IV. DECONTAMINATION DURING MEDICAL EMERGENCIES

A. Basic Considerations

Part of overall planning for incident response is managing medical emergencies. Planning should include:

- Training of response team members in advanced first aid and emergency lifesaving methods.
- Arranging with the nearest medical facility for transportation and treatment of injured, and for treatment of personnel suffering from exposure to chemicals.
- Providing consultation services with toxicologists and other medical specialists.
- Having at the incident specialized equipment, for example, emergency eye washes, showers, first aid kits, blankets, stretcher, and a resuscitator.

In addition, the plan should establish procedures for decontaminating personnel with medical problems and injuries. There is the possibility that decontamination may aggravate or cause more serious health effects. If life threatening injuries are received, prompt life-saving first aid and medical treatment should be administered without decontamination, or concurrently with it. Whenever possible, response personnel should accompany contaminated victims to the medical facility to advise on matters involving decontamination.

B. Physical Injury

Physical injuries can range from a sprained ankle to a compound fracture, from a minor cut to massive bleeding. Depending on the seriousness of the injury, treatment may be given at the site by trained response personnel. For more serious injuries, additional assistance may be required at the site or the victim may have to be treated at a medical facility.

Life-saving care should be instituted immediately without considering decontamination. The outside garments can be removed (depending on the weather) if they do not cause delays, interfere with treatment, or aggravate the problem. Respirators and backpack assemblies must always be removed. Fully encapsulating suits or chemical-resistant clothing can be cut away.

If the outer contaminated garments cannot be safely removed, the individual should be wrapped in plastic, rubber, or blankets to help prevent contaminating the inside of ambulances and medical personnel. Outside garments are then removed at the medical facility. No attempt should be made to wash or rinse the victim at the site. One exception would be if it is known that the individual has been contaminated with an extremely toxic or corrosive material which could also cause severe injury or loss of life. For minor medical problems or injuries, the normal decontamination procedure should be followed.

C. Heat Stress

Heat-related illnesses range from heat fatigue to heat stroke, the most serious. Heat stroke requires prompt treatment to prevent irreversible damage or death. Protective clothing may have to be cut off. Less serious forms of heat stress require prompt attention or they may lead to a heat stroke. Unless the victim is obviously contaminated, decontamination should be omitted or minimized and treatment begun immediately.

D. Chemical Exposure

Exposure to chemicals can be divided into two categories:

- Injuries from direct contact, such as acid burns or inhalation of toxic chemicals.
- Potential injury due to gross contamination on clothing or equipment.

For inhaled contaminants treatment can only be by qualified physicians. If the contaminant is on the skin or in the eyes, immediate measures must be taken to counteract the substance's effect. First aid treatment usually is flooding the affected area with water; however, for a few chemicals, water may cause more severe problems.

When protective clothing is grossly contaminated, contaminants may be transferred to treatment personnel or the wearer and cause injuries. Unless severe medical problems have occurred simultaneously with splashes, the protective clothing should be washed off as rapidly as possible and carefully removed.

V. PROTECTION FOR DECONTAMINATION WORKERS

The Level of Protection worn by decontamination workers is determined by:

- Expected or visible contamination on workers.
- Type of contaminant and associated respiratory and skin hazards.
- Total vapor/gas concentrations in the contamination reduction corridor.
- Particulates and specific inorganic or organic vapors in the CRC.
- Results of swipe tests.

A. Level C Use

Level C includes a full-face, canister-type air-purifying respirator, hard hat with face shield (if splash is a problem), chemical-resistant boots and gloves, and protective clothing. The body covering recommended is chemical-resistant overalls with an apron, or chemical-resistant overalls and jacket.

A face shield is recommended to protect against splashes because respirators alone may not provide this protection. The respirator should have a canister approved for filtering any specific known contaminants such as ammonia, organic vapors, acid gases, and particulates.

B. Level B Use

In situations where site workers may be contaminated with unknowns, highly volatile liquids, or highly toxic materials, decontamination workers should wear Level B protection.

Level B protection includes SCBA, hard hat with face shield, chemical-resistant gloves and boots, and protective covering. The clothing suggested is chemical-resistant overalls, jacket, and a rubber apron. The rubber apron protects the SCBA harness assembly and regulator from becoming contaminated.

VI. DECONTAMINATION OF EQUIPMENT

Insofar as possible, measures should be taken to prevent contamination of sampling and monitoring equipment. Sampling devices become contaminated, but monitoring instruments, unless they are splashed, usually do not. Once contaminated, instruments are difficult to clean without damaging them. Any delicate instrument which cannot be easily decontaminated should be protected while it is being used. It should be placed in a clear plastic bag, and the bag taped and secured around the instrument. Openings are made in the bag for sample intake and exhaust.

A. Decontamination Procedures

1. Sampling devices

Sampling devices require special cleaning. The EPA Regional Laboratories can provide information on proper decontamination methods.

2. Tools

Wooden tools are difficult to decontaminate because they absorb chemicals. They should be kept on site and handled only by protected workers. At the end of the response, wooden tools should be discarded. For decontaminating other tools, Regional Laboratories should be consulted.

3. Respirators

Certain parts of contaminated respirators, such as the harness assembly and straps, are difficult to decontaminate. If grossly contaminated, they may have to be discarded. Rubber components can be soaked in soap and water and scrubbed with a brush. Regulators must be maintained according to manufacturer's recommendations. Persons responsible for decontaminating respirators should be thoroughly trained in respirator maintenance.

4. Heavy Equipment

Bulldozers, trucks, back-hoes, bulking chambers, and other heavy equipment are difficult to decontaminate. The method generally used is to wash them with water under high pressure or to scrub accessible parts with detergent/water solution under pressure. In some cases, shovels, scoops, and lifts have been sand blasted or steam cleaned. Particular care must be given to those components in direct contact with contaminants such as tires and scoops. Swipe tests should be utilized to measure effectiveness. Personnel doing the decontamination must be adequately protected for the methods used can generate contaminated mists and aerosols.

B. Sanitizing of Personnel Protective Equipment

Respirators, reusable protective clothing, and other personal articles not only must be decontaminated before being reused, but also sanitized. The inside of masks and clothing becomes soiled due to exhalation, body oils, and perspiration. The manufacturer's instructions should be used to sanitize the respirator mask. If practical, protective clothing should be machine washed (in a dedicated unit) after a thorough decontamination; otherwise they must be cleaned by hand.

C. Persistent Contamination

In some instances, clothing and equipment will become contaminated with substances that cannot be removed by normal decontamination procedures. A solvent may be used to remove such contamination from equipment if it does not destroy or degrade the protective material. If persistent contamination is expected, disposable garments should be used. Testing for persistent contamination of protective clothing and appropriate decontamination must be done by qualified laboratory personnel.

D. Disposal of Contaminated Materials

All materials and equipment used for decontamination must be disposed of properly. Clothing, tools, buckets, brushes, and all other equipment that is contaminated must be secured in drums or other containers and labeled. Clothing not completely decontaminated on-site should be secured in plastic bags before being removed from the site.

Contaminated wash and rinse solutions should be contained by using step-in-containers (for example, child's wading pool) to hold spent solutions. Another containment method is to dig a trench about 4 inches deep and line it with plastic. In both cases the spent solutions are transferred to drums, which are labeled and disposed of with other substances on site.

VII. ANNEXES

Annex 4, 5, and 6 describe basic decontamination procedures for a worker wearing Level A, B, or C protection. The basic decontamination lines (Situation 1), consisting of approximately 19 stations, are almost identical except for changes necessitated by different protective clothing or respirators. For each annex, three specific situations are described in which the basic (or full decontamination) procedure is changed to take into account differences in the extent of contamination, the accompanying changes in equipment worn, and other factors. The situations illustrate decontamination setups based on known or assumed conditions at an incident. Many other variations are possible.

Annex 7 describes a minimum layout for Level A personnel decontamination. The number of individual stations have been reduced. Although the decontamination equipment and amount of space required is less than needed in the procedures previously described, there is also a much higher probability of cross-contamination.

ANNEX 4

LEVEL A DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level A protection (with taped joints between gloves, boots, and suit) consisting of:

- Fully encapsulating suit.
- Self-contained breathing apparatus.
- Hard hat (optional).
- Chemical-resistant, steel toe and shank boots.
- Boot covers.
- Inner and outer gloves.

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/ water.

Equipment:
- container (20-30 gallons)
- decon solution or detergent water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons)
  or high-pressure spray unit
  water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash fully encapsulating suit and boots. Scrub suit and boots with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons)
- decon solution or detergent/water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 8: Suit/Safety Boot Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons) or high-pressure spray unit
- water
- 2-3 long handle, soft-bristle scrub-brushes

Station 9: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boots covers donned, and joints taped. Worker then returns to duty.

Equipment:
- air tanks
- tape
- boot covers
- gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool
- boot jack

Station 11: Fully Encapsulating Suit and Hard Hat Removal

With assistance of helper, remove fully encapsulating suit (and hard hat). Hang suits on rack or lay out on drop cloths.

Equipment:
- rack
- drop cloths
- bench or stool

Station 12: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment:
- table

Station 13: Inner Glove Wash

Wash with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment:
- basin or bucket
- decon solution or detergent/water
- small table

Station 14: Inner Glove Rinse

Rinse with water. Repeat as many times as necessary.

Equipment:
- water basin
- basin or bucket
- small table

Station 15: Facepiece Removal

Remove facepiece. Deposit in container with plastic liner. Avoid touching face with fingers.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 16: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 17: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Inner clothing should be removed as soon as possible since there is a possibility that small amounts of contaminants might have been transferred in removing fully encapsulating suit.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 18: Field Wash

Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment:
- water
- soap
- small table
- basin or bucket, or
- field showers
- towels

Station 19: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment:
- tables
- chairs
- lockers
- clothes

C. FULL DECONTAMINATION (SITUATION 1) AND THREE MODIFICATIONS (SITUATION 1, 2, AND 3)

	STATION NUMBER																		
SIT.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X										
3	X						X	X		X	X	X			X	X	X	X	
4	X						X	X	X										

Situation 1: The individual entering the Contamination Reduction Corridor is observed to be grossly contaminated or extremely toxic substances are known or suspected to be present.

Situation 2: Same as Situation 1 except individual needs new air tank and will return to Exclusion Zone.

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely toxic or skin-corrosive materials are not present. No outer gloves or boot covers are worn. Inner gloves are not contaminated.

Situation 4: Same as Situation 3 except individual needs new air tank and will return to Exclusion Zone.

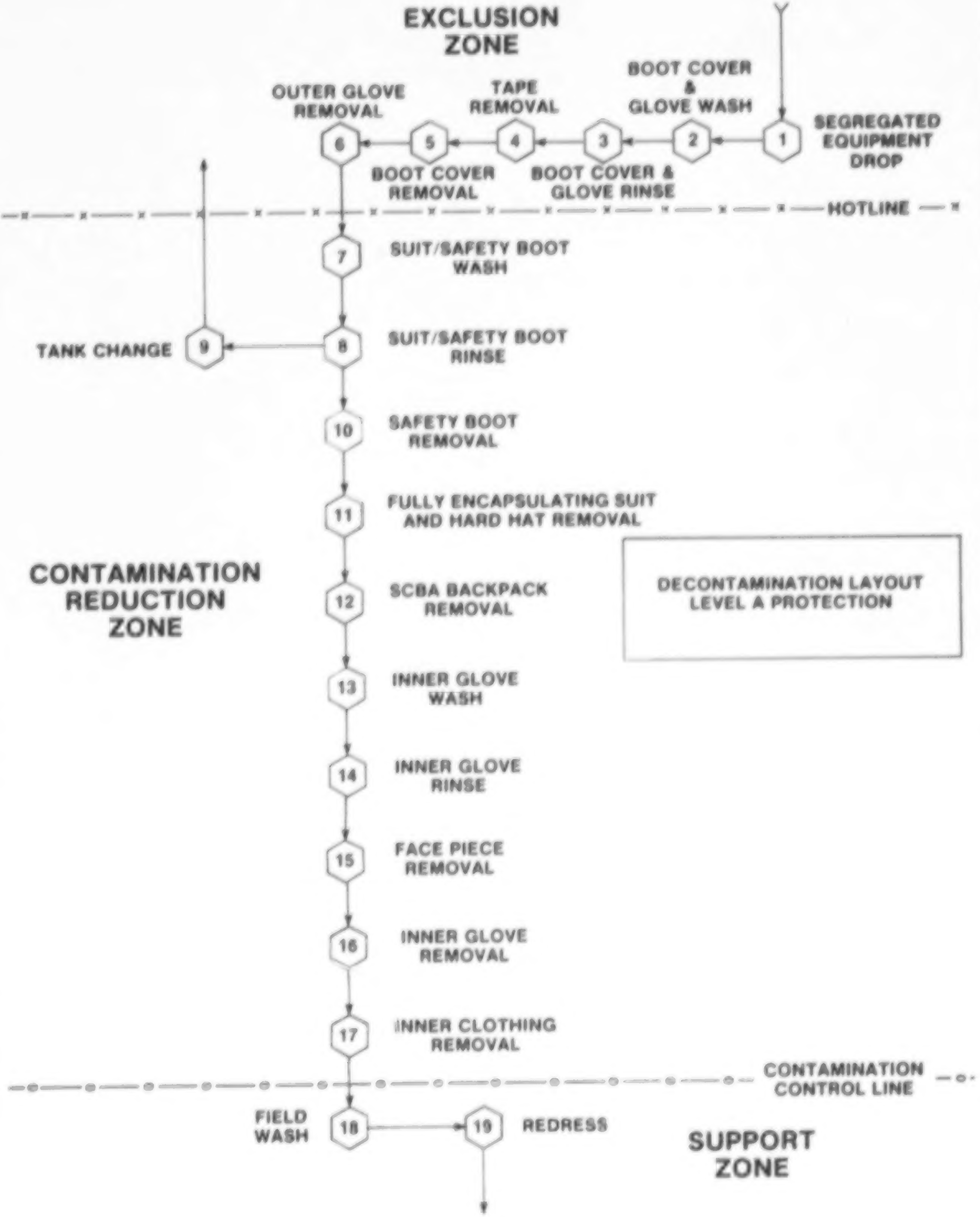

EXCLUSION ZONE
OUTER GLOVE REMOVAL
TAPE REMOVAL
BOOT COVER & GLOVE WASH
SEGREGATED EQUIPMENT DROP
1
2
3
4
5
6
BOOT COVER REMOVAL
BOOT COVER & GLOVE RINSE
HOTLINE
7
SUIT/SAFETY BOOT WASH
TANK CHANGE
9
8
SUIT/SAFETY BOOT RINSE
10
SAFETY BOOT REMOVAL
11
FULLY ENCAPSULATING SUIT AND HARD HAT REMOVAL
DECONTAMINATION LAYOUT LEVEL A PROTECTION
CONTAMINATION REDUCTION ZONE
12
SCBA BACKPACK REMOVAL
13
INNER GLOVE WASH
14
INNER GLOVE RINSE
15
FACE PIECE REMOVAL
16
INNER GLOVE REMOVAL
17
INNER CLOTHING REMOVAL
CONTAMINATION CONTROL LINE
FIELD WASH
18
19
REDRESS
SUPPORT ZONE

FIGURE A4-1

ANNEX 5

LEVEL B DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level B protection (with taped joints between gloves, boot, and suit) consisting of:

- One-piece, hooded, chemical-resistant splash suit.
- Self-contained breathing apparatus.
- Hard hat.
- Chemical-resistant, steel toe and shank boots.
- Boot covers
- Inner and outer gloves.

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/ water.

Equipment:
- container (20-30 gallons)
- decon solution or
- detergent water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons) or
- high-pressure spray unit
- water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons
- plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash chemical-resistant splash suit, SCBA, gloves, and safety boots. Scrub with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Wrap SCBA regulator (if belt-mounted type) with plastic to keep out water. Wash backpack assembly with sponges or cloths.

Equipment:
- container (30-50 gallons)
- decon solution or
- detergent/water
- 2-3 long-handle, soft-bristle scrub-brushes

- small buckets
- sponges or cloths

Station 8: Suit/SCBA/Boot/Glove Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons) or
- high-pressure spray unit
- water
- small buckets
- 2-3 long-handle, soft-bristle scrub-brushes
- sponges or cloths

Station 9: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boots covers donned, and joints taped. Worker returns to duty.

Equipment:
- air tanks
- tape
- boot covers
- gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool
- boot jack

Station 11: SCBA Backpack Removal

While still wearing facepiece, remove backpack and place on table. Disconnect hose from regulator valve and proceed to next station.

Equipment:
- table

Station 12: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 13: Inner Glove Wash

Wash inner gloves with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment:
- decon solution or
- detergent/water
- basin or bucket
- small table

Station 14: Inner Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment:
- water
- basin or bucket
- small table

Station 15: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 16: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 17: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off-site since there is a possibility small amounts of contaminants might have been transferred in removing fully encapsulating suit.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 18: Field Wash

Shower if highly toxic, skin-corrosive, or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment:
- water
- soap
- small tables
- basins or buckets, or
- field showers

Station 19: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment:
- tables
- chairs
- lockers
- clothes

C. FULL DECONTAMINATION (SITUATION 1) AND THREE MODIFICATIONS (SITUATION 1, 2, AND 3)

	STATION NUMBER																		
SIT.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X										
3	X						X	X		X	X	X			X	X	X	X	
4	X						X	X	X										

Situation 1: The individual entering the Contamination Reduction Corridor is observed to be grossly contaminated or extremely toxic substances are known or suspected to be present.

Situation 2: Same as Situation 1 except individual needs new air tank and will return to Exclusion Zone.

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely toxic or skin-corrosive materials are not present No outer gloves or boot covers are worn. Inner gloves are not contaminated.

Situation 4: Same as Situation 3 except individual needs new air tank and will return to Exclusion Zone.

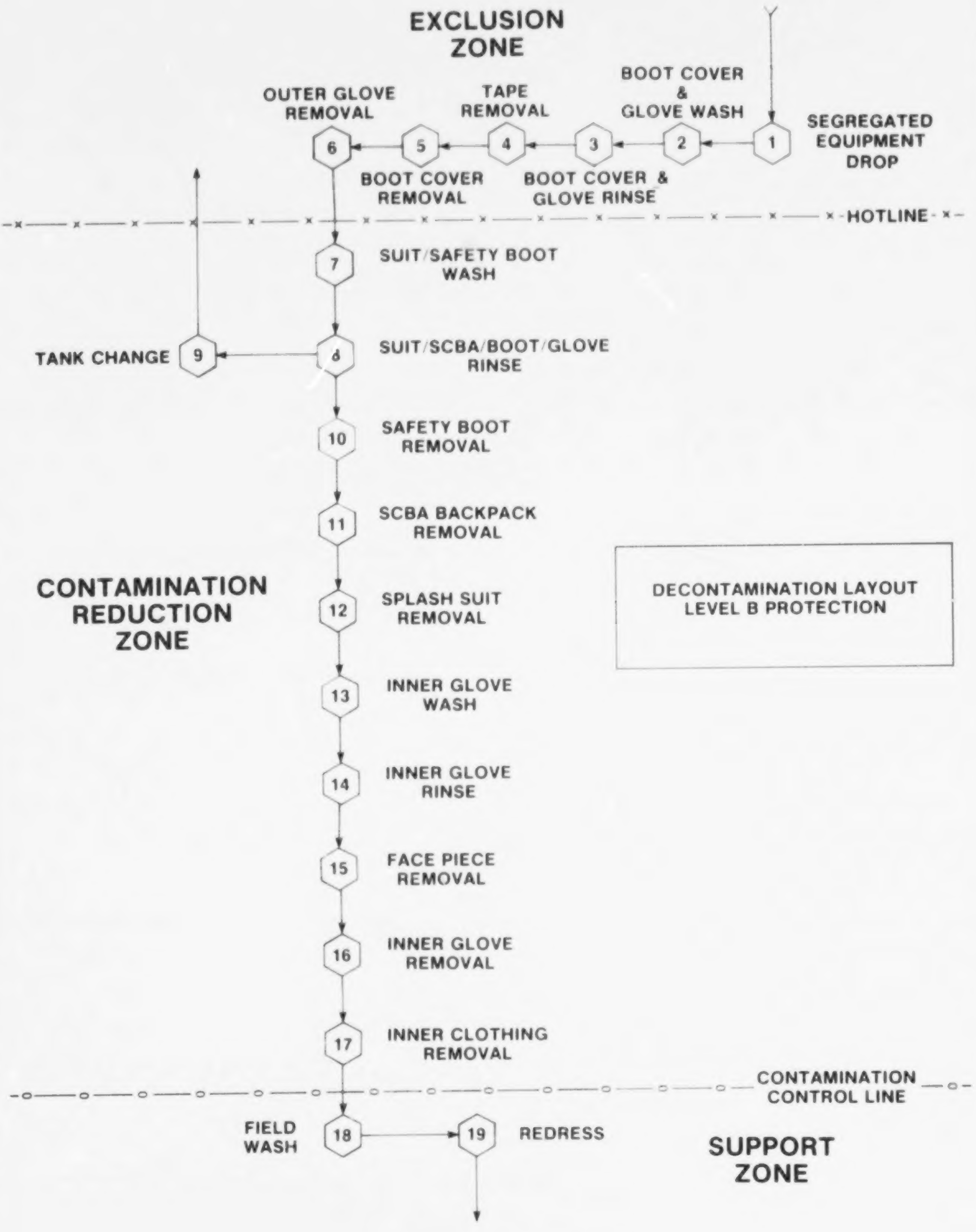

EXCLUSION ZONE
OUTER GLOVE REMOVAL
TAPE REMOVAL
BOOT COVER & GLOVE WASH
SEGREGATED EQUIPMENT DROP
6
5
4
3
2
1
BOOT COVER REMOVAL
BOOT COVER & GLOVE RINSE
HOTLINE
7
SUIT/SAFETY BOOT WASH
TANK CHANGE
9
8
SUIT/SCBA/BOOT/GLOVE RINSE
10
SAFETY BOOT REMOVAL
11
SCBA BACKPACK REMOVAL
CONTAMINATION REDUCTION ZONE
12
SPLASH SUIT REMOVAL
DECONTAMINATION LAYOUT LEVEL B PROTECTION
13
INNER GLOVE WASH
14
INNER GLOVE RINSE
15
FACE PIECE REMOVAL
16
INNER GLOVE REMOVAL
17
INNER CLOTHING REMOVAL
CONTAMINATION CONTROL LINE
FIELD WASH
18
19
REDRESS
SUPPORT ZONE

FIGURE A5-1

ANNEX 6

LEVEL C DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level C protection (with taped joints between gloves, boots, and suit) consisting of:

- One-piece, hooded, chemical-resistant splash suit.
- Canister equipped, full-face mask.
- Hard hat.
- Chemical-resistant, steel toe and shank boots.
- Boot covers.
- Inner and outer gloves.

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/ water.

Equipment:
- container (20-30 gallons)
- decon solution or
- detergent water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons) or
- high-pressure spray unit
- water
- 2-3 long-handle, soft bristle scrub-brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash splash suit and safety boots. Scrub with long handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons)
- decon solution or
- detergent/water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 8: Suit/Safety Boot Rinse

Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment:
- container (30-50 gallons) or
- high-pressure spray unit
  water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 9: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boots covers donned, and joints taped. Worker returns to duty.

Equipment:
- canister (or mask)
- tape
- boot covers
- gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool
- boot jack

Station 11: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- bench or stool
- liner

Station 12: Inner Glove Wash

Wash inner gloves with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment:
- decon solution or
- detergent/water
- basin or bucket

Station 13: Inner Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment:
- water
- basin or bucket
- small table

Station 14: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit facepiece in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 15: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment:
- container (20-30 gallons)
- plastic liners

Station 16: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off-site since there is a possibility small amounts of contaminants might have been transferred in removing splash suite.

Equipment:
- container (30-50 gallons)
- plastic liners

Station 17: Field Wash

Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment:
- water
- soap
- tables
- wash basins/buckets, or

- field showers

Station 18: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment:
- tables
- chairs
- lockers
- clothes

C. FULL DECONTAMINATION (SITUATION 1) AND THREE MODIFICATIONS (SITUATION 2, 3, & 4)

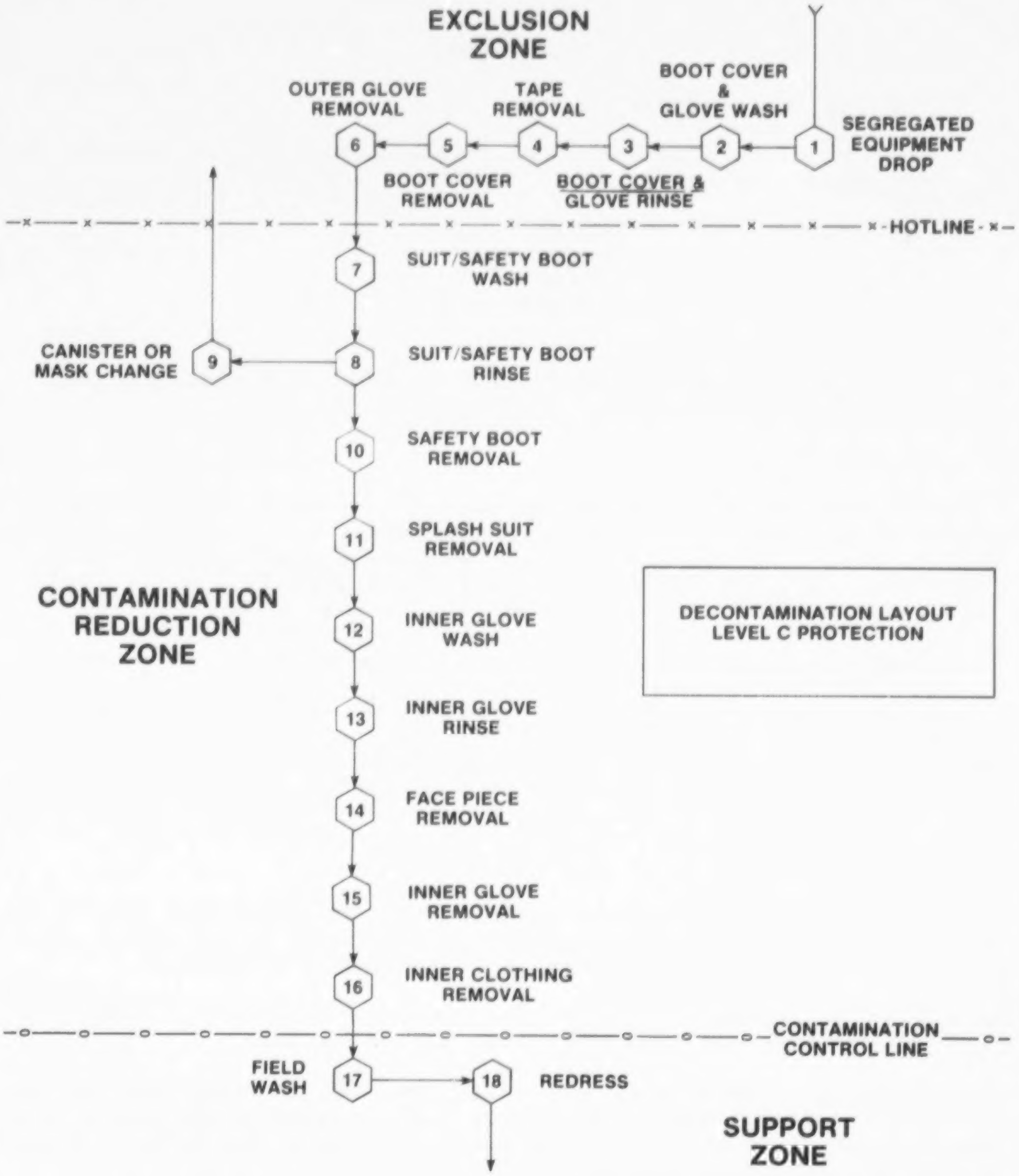
	STATION NUMBER																	
SIT.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X									
3	X						X	X		X	X			X	X	X	X	
4	X						X	X	X									

Situation 1: The individual entering the Contamination Reduction Corridor is observed to be grossly contaminated or extremely skin corrosive substances are known or suspected to be present.

Situation 2: Same as Situation 1 except individual needs new canister or mask and will return to Exclusion Zone.

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely skin-corrosive materials are not present. No outer gloves or boot covers are worn. Inner gloves are not contaminated.

Situation 4: Same as Situation 3 except individual needs new canister or mask and will return to Exclusion Zone.


EXCLUSION ZONE
OUTER GLOVE REMOVAL
TAPE REMOVAL
BOOT COVER & GLOVE WASH
SEGREGATED EQUIPMENT DROP
6
5
4
3
2
1
BOOT COVER REMOVAL
BOOT COVER & GLOVE RINSE
HOTLINE
7
SUIT/SAFETY BOOT WASH
CANISTER OR MASK CHANGE
9
8
SUIT/SAFETY BOOT RINSE
10
SAFETY BOOT REMOVAL
11
SPLASH SUIT REMOVAL
CONTAMINATION REDUCTION ZONE
12
INNER GLOVE WASH
13
INNER GLOVE RINSE
14
FACE PIECE REMOVAL
15
INNER GLOVE REMOVAL
16
INNER CLOTHING REMOVAL
CONTAMINATION CONTROL LINE
FIELD WASH
17
18
REDRESS
SUPPORT ZONE

DECONTAMINATION LAYOUT
LEVEL C PROTECTION

FIGURE A6-1

ANNEX 7

LEVEL A DECONTAMINATION, MINIMUM LAYOUT

A. EQUIPMENT WORN

The decontamination procedure outlined is for workers wearing Level A protection (with taped joints between gloves, boots, and suit) consisting of:

- Fully encapsulating suit with integral boots and gloves.
- Self-contained breathing apparatus.
- Hard hat (optional).
- Chemical-resistant, steel toe and shank boots.
- Boot covers.
- Inner and outer gloves.

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment:
- various size containers
- plastic liners
- plastic drop clothes

Station 2: Outer Garment, Boots, and Gloves Wash and Rinse

Scrub outer boots, outer gloves, and fully-encapsulating suit with decon solution or detergent water. Rinse off using copious amounts of water.

Equipment:
- containers (30-50 gallons)
- decon solution or
- detergent water
- rinse water
- 2-3 long-handle, soft-bristle scrub-brushes

Station 3: Outer Boot and Glove Removal

Remove outer boots and gloves. Deposit in container with plastic liner.

Equipment:
- container (30-50 gallons)
- plastic liners
- bench or stool

Station 4: Tank Change

If worker leaves Exclusion Zone to change air tank, this is the last step in the decontamination procedure. Worker's air tank is exchanged, new outer gloves and boot covers donned, joints taped, and worker returns to duty.

Equipment:
- air tanks
- tape
- boot covers
- gloves

Station 5: Boot, Gloves, and Outer Garment Removal

Boots, fully-encapsulating suit, and inner gloves removed and deposited in separate containers lined with plastic.

Equipment:
- containers (30-50 gallons)
- plastic liners
- bench or stool

Station 6: SCBA Removal

SCBA backpack and facepiece is removed. Hands and face are thoroughly washed. SCBA deposited on plastic sheets.

Equipment:
- plastic sheets
- basin or bucket
- soap and towels
- bench

Station 7: Field Wash

Thoroughly wash hands and face. Shower as soon as possible.

Equipment:
- water
- soap
- tables
- wash basin/bucket

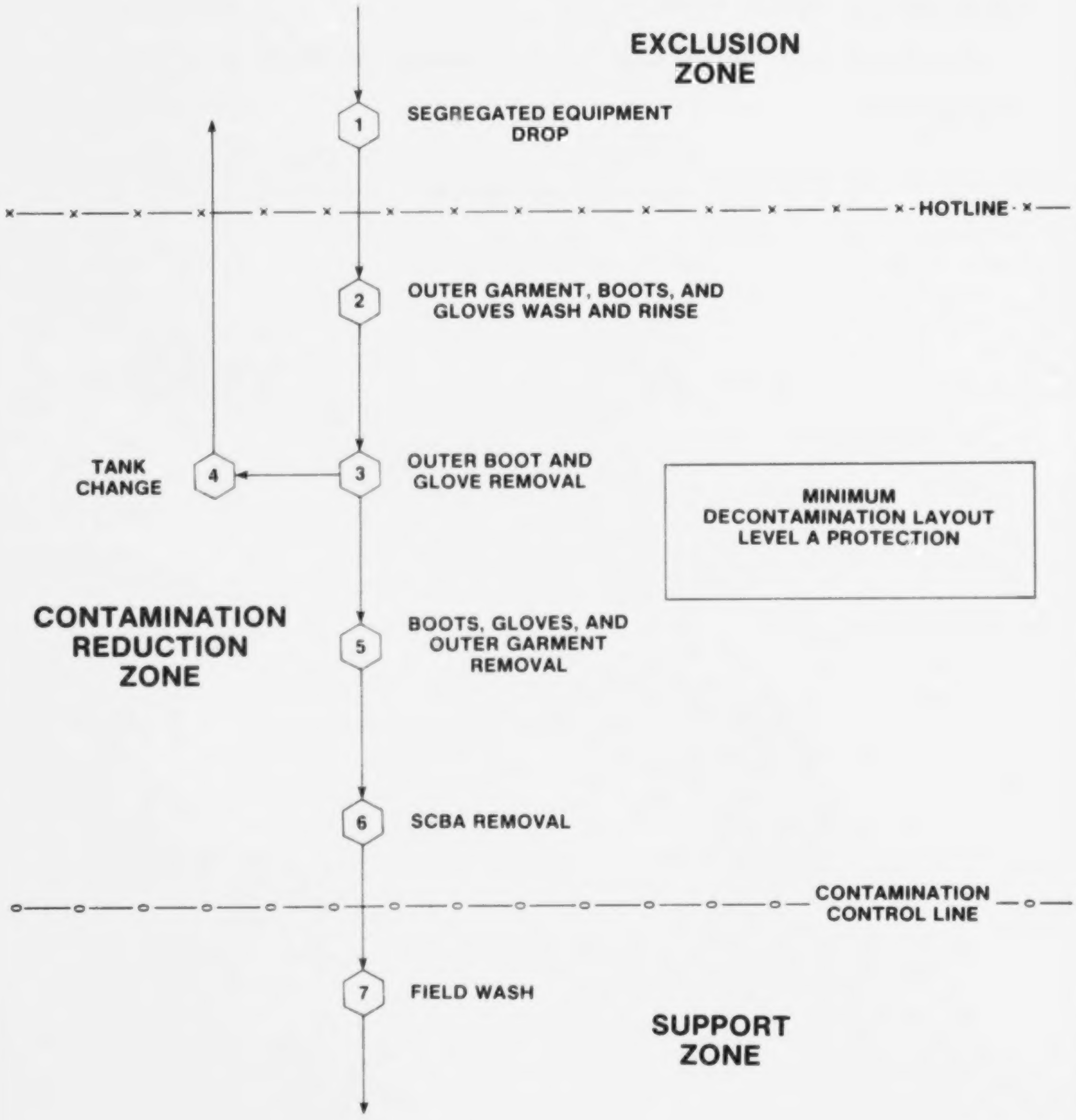

EXCLUSION ZONE
1
SEGREGATED EQUIPMENT DROP
HOTLINE
2
OUTER GARMENT, BOOTS, AND GLOVES WASH AND RINSE
TANK CHANGE
4
3
OUTER BOOT AND GLOVE REMOVAL
MINIMUM DECONTAMINATION LAYOUT LEVEL A PROTECTION
CONTAMINATION REDUCTION ZONE
5
BOOTS, GLOVES, AND OUTER GARMENT REMOVAL
6
SCBA REMOVAL
CONTAMINATION CONTROL LINE
7
FIELD WASH
SUPPORT ZONE

FIGURE A7-1

PART 10

AIR SURVEILLANCE

I. INTRODUCTION

Accidents involving hazardous materials or remedial actions at abandoned waste sites can release a variety of substances into the air. Chemical fires, transportation accidents, open or leaking containers, wind-blown dust, and site cleanup activities produce emissions which can rapidly affect the health and safety of response personnel and the public. Hazardous atmospheres can involve:

- Ignitable or explosive vapors, gases, aerosols, and dusts (explosive atmosphere).
- Toxic vapors, gases, and aerosols (toxic atmosphere).
- Displacement of breathable air (oxygen-deficient atmosphere).
- Radioactive materials (radioactive environment).

The presence of one or more of these hazards determines subsequent actions to protect people or the environment, operations to mitigate the incident, and safety considerations for response personnel.

Airborne hazards can be predicted if the substance involved, its chemical and physical properties, and weather conditions are known. But air surveillance is necessary to confirm predictions, to identify or measure contaminants, or to detect unknown air pollutants.

This part provides guidance primarily on longer-term air sampling for toxic substances. Information is given in Part 5, Initial Site Survey and Reconnaissance, regarding initial characterization of airborne hazards.

II. OBJECTIVE OF AIR SURVEILLANCE

Air surveillance consists of air monitoring (using direct-reading instruments capable of providing real-time indications of air contaminants) and air sampling (collecting air on an appropriate media or in a suitable sampling container followed by analysis).

The objective of air surveillance during response is to identify and quantify airborne contaminants on and off-site, and monitor changes in air contaminants that occur over the lifetime of the incident.

The data obtained are used to help establish criteria for worker safety, document potential exposures, determine protective measures for the public, evaluate the environmental impact of the incident, and determine mitigation activities. Accomplishing this requires establishing an effective air surveillance program tailored to meet the conditions generated by each incident.

III. TYPES OF INCIDENTS

As part of initial hazard evaluation, direct-reading instruments (DRIs), visible indicators (signs, labels, placards, type of container, etc.), and other information (manifests, railroad consists, inventories, government agency records, etc.) are used to evaluate the presence or potential for air contaminant release. Limited air sampling may also be conducted if time is available. Based on an assessment of this preliminary information, a more comprehensive air surveillance strategy is developed and implemented.

Two general types of incidents are encountered:

- Environmental emergencies: Includes chemical fires, spills, or other releases of hazardous materials which occur over a relatively short period of time. Since contaminants may be released rapidly, there may be no time for air surveillance. In incidents where the released material can be quickly identified (and sufficient time is available), direct-reading, hand-held monitoring instruments can be used to provide information on some types of hazards. Air sampling generally is limited unless the release continues long enough for appropriate equipment to be brought in.

- Longer-term cleanup: Includes planned removals and remedial actions at abandoned waste sites as well as restoration after emergency problems have been controlled. During this period, especially at waste sites, workers and the public may be exposed to a wide variety of airborne materials over a much longer period of time. Since long term cleanup activities require more time (and planning) to accomplish, appropriate equipment for air monitoring and sampling can be secured, and an air surveillance program established.

IV. GENERAL SURVEILLANCE METHODS

During site operations, data are needed about air contaminants and any changes that may occur. These changes can include start-up of work in a different part of the site, discovery of contaminants other than those expected, and initiation of different types of work. Surveillance for vapors, gases, and particulates is done using DRIs and air sampling systems. DRIs can be used to detect many organics and a few inorganics and provide approximate total concentrations. If specific organics (and inorganics) have been identified, then DRIs, calibrated to those materials, can be used for more accurate on-site assessment. In many instances however, only air sampling (and laboratory analysis) can be used for detection and quantification.

The most accurate method for evaluating any air contaminant is to collect samples and analyze them at a reliable laboratory. Although accurate, this method has two disadvantages: cost and the time required to obtain results. Analyzing large numbers of samples in laboratories is very expensive, especially if results are needed quickly. On-site laboratories tend to reduce the turn-around time, but unless they can analyze other types of samples, they also are costly. In emergencies, time is often not available for laboratory analysis of samples either on-site or off-site.

To obtain air monitoring data rapidly at the site, instruments utilizing flame ionization detectors (FIDs) photoionization detectors (PIDs) and other similar instruments can be used. These may be used as survey instruments (total concentration mode) or operated as gas chromatographs (gas chromatograph mode). As gas chromatographs, these instruments can provide real-time, qualitative/quantitative data when calibrated with standards of known air contaminants. Combined with selective laboratory analysis of samples, they provide a tool for evaluating airborne organic hazards on a real-time basis, at a lower cost than analyzing all samples in a laboratory. An example of an air surveillance program used by the U.S. Environmental Protection Agency's Environmental Response Team is contained in Annex 8.

V. AIR SAMPLING STRATEGIES

For more complete information about air contaminants, measurements obtained with DRIs must be supplemented by collecting and analyzing air samples. To assess air contaminants more thoroughly, air sampling devices equipped with appropriate collection media are placed at various locations throughout the area. These samples provide air quality information for the period of time they operate, and can indicate contaminant types and concentrations over the lifetime of site operations. As data are obtained (from the analysis of samples, DRIs, knowledge about materials involved, site operations, and potential for airborne toxic hazards), adjustments are made in the type of samples, number of samples collected, frequency of sampling, and analysis required. In addition to air samplers, area sampling stations may also include DRIs equipped with recorders and operated as continuous air monitors. Area sampling stations are located in various places including:

- Upwind - Because many hazardous incidents occur near industries or highways that generate air pollutants, samples must be taken upwind of the site, and any other potential source of contaminants, to establish background levels of air contaminants.

- Support Zone - Samples must be taken near the command post or other support facilities to ensure that they are in fact located in a clean area, and that the area remains clean throughout operations at the site.

- Contamination Reduction Zone - Air samples should be collected along the decontamination line to ensure that decontamination personnel are properly protected and that on-site workers are not removing their protective gear in a contaminated area.

- Exclusion zone - The exclusion zone presents the greatest risk of exposure to chemicals and requires the most air sampling. The location of sampling stations should be based upon hot-spots or source areas detected by DRIs, types of substances present, and potential for airborne contaminants. The data from these stations, in conjunction with intermittent walk-around surveys with DRIs, are used to verify the selection of proper levels of personnel protection, set exclusion zone boundaries, as well as to provide a continual record of air contaminants.

- Downwind - Sampling stations are located downwind from the site to determine if any air contaminants are migrating from the site. If there are indications of airborne hazards in populated areas, additional samplers should be placed downwind.

VI. MEDIA FOR COLLECTING AIR SAMPLES

Hazardous material incidents, especially abandoned waste sites, involve many potentially dangerous substances including gases, vapors, and aerosols that could become airborne. A variety of media - liquids and solids - are used to collect these substances. Sampling systems typically include a calibrated air sampling pump which draws air into selected collection media. Some of the most common types of samples, and the collection media used for them are:

- Organic vapors: Activated carbon is an excellent sorbent for most organic vapors. However, other solid sorbents (such as Tenax, silica gel, and Florisil) are routinely used to sample specific organic compounds or classes of compounds that do not adsorb or desorb well on activated carbon. To avoid stocking a large number of sorbents for all substances anticipated, a smaller number chosen for collecting the widest range of materials or for substances known to be present generally are used. The samples are collected using an industrial hygiene personal sampling pump with either one sampling port or a manifold system capable of simultaneously collecting samples on several sorbent tubes. Individual pumps with varying flow rates may also be used to collect several samples at once. The tubes might contain:

    - Activated carbon to collect vapors of materials with a boiling point above 0 degrees centigrade. These materials include most odorous organic substances, such as solvent vapors.

    - A porous polymer such as Tenax or Chromosorb to collect substances (such as high-molecular-weight hydrocarbons, organophosphorus compounds, and the vapors of certain pesticides) that adsorb poorly onto activated carbon. Some of these porous polymers also adsorb organic materials at low ambient temperatures more efficiently than carbon.

    - A polar sorbent such as silica gel to collect organic vapors (aromatic amines, for example) that exhibit a relatively high dipole moment.

  - -- Any other specialty adsorbent selected for the specific site. For example, a Florisil tube could be used if polychlorinated biphenyls are suspected.

- Inorganic gases: The inorganic gases present at an incident would primarily be polar compounds such as the haloacid gases. They can be adsorbed onto silica gel tubes and analyzed by ion chromatography. Impingers filled with selected liquid reagents can also be used.

- Aerosols: Aerosols (solid or liquid particulates) that may be encountered at an incident include contaminated and non-contaminated soil particles, heavy-metal particulates, pesticide dusts, and droplets of organic or inorganic liquids. An effective method for sampling these materials is to collect them on a particulate filter such as a glass fiber or membrane type. A backup impinger filled with a selected absorbing solution may also be necessary.

Colorimetric detector tubes can also be used with a sampling pump when monitoring for some specific compounds. Passive organic vapor monitors can be substituted for the active system described if passive monitors are available for the types of materials suspected to be present at a given site.

The National Institute for Occupational Safety and Health's (NIOSH) Manual of Analytical Methods, (Volumes 1-3, 2nd. & 3rd. Editions) contains acceptable methods for collecting and analyzing air samples for a variety of chemical substances. Consult it for specific procedures.

VII. COLLECTION AND ANALYSIS

Samples are analyzed to determine types and quantities of substances present. The following provides additional guidance on sample collection and analysis.

- Aerosols

  Samples for aerosols should be taken at a relatively high flow rate (generally about 2 liters/minute) using a standard industrial hygiene pump and filter assembly. To collect total particulates, a membrane filter having a 0.8 micrometer pore size is common. The sample can be weighed to determine total particulates, then analyzed destructively or non-destructively for metals. If the metals analysis is done nondestructively or if the filter is sectioned, additional analyses (for example, organics, inorganics, and optical particle sizing) can be performed.

- Sorbent Samples

  The sorbent material chosen, the amount used, and sample volume will vary according to the types and concentrations of substances anticipated at a particular site. Polar sorbent material such as silica gel will collect polar substances which are not adsorbed well onto activated carbon and some of the porous polymers. The silica gel sample can be split and analyzed for the haloacid gases and aromatic amines.

  Activated carbon and porous polymers will collect a wide range of compounds. Exhaustive analysis to identify and quantify all the collected species is prohibitively expensive at any laboratory and technically difficult for a field laboratory. Therefore, samples should be analyzed for principal hazardous constituents (PHCs). The selection of PHCs should be based upon the types of materials anticipated at a given site, from generator's records, and from information collected during the initial site survey. To aid in the selection of PHCs, a sample could be collected on activated carbon or porous polymer during the initial site survey and exhaustively analyzed off-site to identify the major peaks within selected categories.

  This one thorough analysis, along with what is already known about a particular site, could provide enough information to select PHCs. Standards of PHCs could then be prepared and used to calibrate instruments used for field analysis of samples. Subsequent, routine off-site analysis could be limited to scanning for only PHCs, saving time and money. Special adsorbents and sampling conditions can be used for specific PHCs if desired while continued multimedia sampling provides a base for analysis of additional PHCs that may be identified during the course of cleanup operations.

- Passive Dosimeters

  A less traditional method of sampling is the use of passive dosimeters. The few passive dosimeters now available are only for gases and vapors. Passive dosimeters are used primarily to monitor personal exposure, but they can be used to monitor areas. Passive monitors are divided into two groups:

- Diffusion samplers, in which molecules move across a concentration gradient, usually achieved within a stagnant layer of air, between the contaminated atmosphere and the indicator material.
- Permeation devices, which rely on the natural permeation of a contaminant through a membrane. A suitable membrane is selected that is easily permeated by the contaminant of interest and impermeable to all others. Permeation dosimeters are therefore useful in picking out a single contaminant from a mixture of possible interfering contaminants.

Some passive dosimeters may be read directly, as are DRIs and colorimetric length-of-stain tubes. Others require laboratory analysis similar to that done on solid sorbents.

VIII. PERSONNEL MONITORING

In addition to area atmospheric sampling, personnel monitoring - both active and passive - can be used to sample for air contaminants. Representative workers are equipped with personal samplers to indicate contaminants at specific locations or for specific work being done. Placed in workers breathing zone, generally within 1 foot of the mouth and nose, the monitors indicate the potential for the worker to inhale the contaminant.

IX. CALIBRATION

As a rule, the total air sampling system should be calibrated rather than the pump alone. Proper calibration is essential for correct operation and for accurate interpretation of resultant data. At a minimum, the system should be calibrated prior to and after use. The overall frequency of calibration will depend upon the general handling and use of a given sampling system. Pump mechanisms should be recalibrated after repair, when newly purchased, and following suspected abuse. Calibration methods can be found in the NIOSH Manual of Analytical Methods.

X. METEOROLOGICAL CONSIDERATIONS

Meteorological information is an integral part of an air surveillance program. Data concerning wind speed and direction, temperature, barometric pressure, and humidity, singularly or in combination, are needed for:

- Selecting air sampling locations.
- Calculating air dispersion.
- Calibrating instruments.
- Determining population at risk or environmental exposure from airborne contaminants.

Knowledge of wind speed and direction is necessary to effectively place air samplers. It is particularly important in source-oriented ambient air sampling that samplers be located at varying distances downwind from the source, as well as to collect background air samples upwind from the source. Shifts in wind direction must be known and samplers relocated or corrections made for the shifts. In addition, atmospheric simulation models for predicting contaminant dispersion and concentration need windspeed and direction as inputs for predictive calculations. Information may be needed concerning the frequency and intensity of winds from certain directions (windrose data). Consequently, the wind direction must be continually monitored.

Air sampling systems need to be calibrated before use and corrections in the calibration curves made for temperature and pressure. After sampling, sampled air volumes are also corrected for temperature and pressure variations. This requires data on air temperature and pressure during sampling.

Air sampling is sometimes designed to assess population exposure (and frequently potential worker exposure). Air samplers are generally located in population centers irrespective of wind direction. Even in these instances, however, meteorological data is needed for air dispersion modeling. Models are then used to predict or verify population-oriented sampling results.

Proper data is collected by having meteorological stations on site or obtaining it from one or more government or private organizations which routinely collect such data. The choice of how information is obtained depends on the availability of reliable data at the location desired, resources needed to obtain meteorological equipment, accuracy of information needed, and the use of the information.

ANNEX 8

GUIDE TO ENVIRONMENTAL RESPONSE TEAM'S AIR SURVEILLANCE PROGRAM

I. APPROACH

A variety of long-term air surveillance programs can be designed to detect a wide range of airborne compounds. To implement any program a number of factors must be considered, including type of equipment, costs, personnel required, accuracy of analysis, time required to obtain results (turn-around-time), and availability of analytical laboratories.

One approach to air surveillance, developed and used by the U.S. EPA Environmental Response Team (ERT), is described here. This program achieves a reasonable balance between cost, accuracy, and time in obtaining data using a combination of direct reading instruments (DRIs) and air sampling systems to:

- Rapidly survey for airborne organic vapors and gases.
- Identify and measure organic vapors and gases.
- Identify and measure particulates and inorganic vapors and gases. The approach is based on:
    - Using flame ionization detectors (FIDs) and/or photoionization detectors (PIDs) for initial detection of total organic gases and vapors and for periodic site surveys (for total organics). Equipped with strip chart recorders, the detectors are used as area monitors to record total organic concentration and changes in concentration over a period of time. Calibrated to specific organic contaminants, they are used to detect and measure those substances.
    - Collecting area air samples using personal pumps and organic gas/ vapor collection tubes. Samples are analyzed using the gas chromatograph (GC) capabilities of field instruments. Selected samples are also analyzed in laboratories accredited by the American Industrial Hygiene Association (AIHA).

-- Using PIDs and/or FIDs (as a survey instrument or GC) to provide real-time data and to screen the number of samples needed for laboratory analysis.

-- Sampling for particulates, inorganic acids, aromatic amines, halogenated pesticides, etc., when they are known to be involved or when there are indications that these substances may be a problem.

II. EQUIPMENT

At present, the following equipment is used for organic gas/vapor monitoring. Other equivalent equipment can be substituted:

- HNU Systems Photoionizer (PID)*
- Foxboro OVA (FID)*
- Photovac GC*
- Gillian Model Number HFS-UT113 Sampling Pump*
- Tedlar Bags (0.5 liters)*
- Tenax adsorption tubes (metal)*
- Carbon-packed adsorption tubes (metal)
- Carbon-packed adsorption tubes (glass)
    - 150 milligram and 600 milligram sizes

III. PROCEDURE

This procedure is generally applicable to most responses. However, since each incident is unique, modifications may be needed.

Organic Gases and Vapors. The sequence for monitoring organic gases and vapors consists of several steps.

- Determine total background concentrations.

(*) The use of brand names does not imply their endorsement by the U.S. EPA

- Determine total concentration on-site.
- Collect on-site area samples.
- Identify specific contaminants.

Background concentrations. Background readings of total organic gases and vapors, using DRIs (FID/PID), are made upwind of the site in areas not expected to contain air contaminants. If industries, highways, or other potential sources contribute to concentrations on-site, these contributions should be determined. Depending on the situation and the time available, additional monitoring should be done nearby to determine if contaminants are leaving the site.

Concentrations on-site. The on-site area is monitored (using DRIs) for total gas/vapor concentrations, measured at both ground and breathing zone levels. The initial walk-throughs are to determine general ambient concentrations and to locate higher-than ambient concentrations (hot-spots).

Transient contributors on-site, for example, exhausts from engines, should be avoided. Concentrations are recorded and plotted on a site map. Additional DRI monitoring is then done to thoroughly define any hot-spots located during the survey.

Area samples. Sampling stations are located throughout the site. The number and locations depend on evaluating many factors, including hotspots (by DRI), active work areas, potentials for high concentrations, and wind direction. As a minimum, stations should be located in a clean off-site area (control or background station), exclusion zone, and downwind of the site. As data are accumulated, location, number of stations, and frequency of sampling can be adjusted.

Routinely, two 4-hour samples are collected, in the morning and afternoon respectively, using personal sampling pumps equipped with Tenax and/or carbon-packed, metal adsorption tubes. Total gas/vapor concentration (using DRI) should also be determined at the start and finish of each sampling run. The readings obtained may show an approximate relationship (depending on organics present) which will be helpful later in placing samplers.

Samples are either collected on media, and desorbed with a thermal desorber or collected in air bags. Samples are then analyzed by a field gas chromatograph (PID or FID) for total organic concentration and number of peaks. Chromatograms of samples taken at the same location but at different times or from different stations can be compared. Differences in heights of "total" peak, number of independent peaks, and relative peak heights, if judiciously interpreted, are useful for making preliminary judgments concerning air contaminant problems.

If relatively high concentrations of chemicals are detected by the initial DRI surveys samplers equipped with carbon-packed collection tubes (glass) and Tenax/carbon-packed (metal) tubes are operated. The latter samples are analyzed in the field. The carbon-packed collection tubes are analyzed by an AIHA accredited laboratory.

Area surveys using DRI are continued routinely two-four times daily. These surveys are to monitor for general ambient levels, as well as levels at sampling stations, hot-spots, and other areas of site activities. As information is accumulated on airborne organics, the frequency of surveys can be adjusted.

Specific contaminants. Personal monitoring pumps with carbon-packed collection tubes (glass) are operated on the first afternoon, concurrent with samplers equipped with Tenax/carbon-packed, metal collection tubes. Generally, when total gas/vapor readings are low and only a few peaks seen (from the field GC analysis of the morning samples), 100-150 mg carbon-packed tubes (glass) are used and operated at a flow rate of 500 cubic centimeters/minute until approximately 100 liters of air have been collected. Depending on suspected contaminants and their concentrations, higher flow rates and/or volumes maybe needed. When total gas/vapor readings are high and there are many peaks (from the morning samples), then larger glass carbon collection tubes (600 mg) are operated at a flow rate from 0.5 to 1 liters/minute to collect 90 to 150 liters of air.

The results from laboratory analysis of glass carbon tubes are used for a number of different purposes, including:

- To identify and measure organic gases and vapors collected during the sampling period.

- To compare laboratory chromatograms and field chromatograms. If only a few peaks (but the same number) are seen on each chromatogram (and identified on the laboratory chromatogram) from samples collected at the same location, it may be reasonable to assume, until standards are run on the field GC, that the two chromatograms are identifying the same materials.

- To identify major contaminants on laboratory chromatograms and to determine what standards to prepare for the field GC. Field GC's can then be used to identify and measure air contaminants against laboratory prepared standards.

- To use the field GC as a screening device for determining when samples should be collected for laboratory analysis, or when samples previously collected should be analyzed. Changes in the number of peaks on the field chromatograms from samples collected at the same location indicate changes in the air, suggesting the need to collect additional samples for laboratory analysis.

If desorption equipment is not available for on-site sample analysis, glass collection tubes or grab samples using a desiccator and tedlar bag setup, should be obtained daily. Samples are then analyzed using a field GC. Only samples collected every third to fifth day are sent to AIHA accredited laboratories for analysis; the remaining samples are stored in a cool place (preferably refrigerated). Selected stored samples are analyzed if third to fifth day samples indicate changes in air contaminant patterns. If daily on-site surveys detect low contaminant(s) levels, then 100-150 mg glass carbon columns are used. If the survey reveals relatively high levels of contaminants, then 600 mg glass carbon tubes are used.

The National Institute for Occupational Safety and Health P&CAM Analytical Method No. 1003, 1500, and 1501 should be followed as closely as possible. Flow rates and collection tubes described in this guide are primarily for organic solvents. If other than organic solvents are suspected, then the NIOSH Manual of Analytical Methods should be consulted for the appropriate collection media and flow rates.

Particulates and Inorganic Gases and Vapors. Sampling for particulates is not done routinely. If these types of air contaminants are known or suspected to be present, a sampling program is instituted for them. Incidents where these contaminants might be present are: fires involving pesticides or chemicals, incidents involving heavy metals, arsenic, or cyanide compounds, or mitigation operations that create dust (from contaminated soil and excavation of contaminated soil).

Sampling media and analytical methods for these air contaminants should follow guidance given in the NIOSH Manual of Analytical Methods.

APPENDIX I

CHARACTERISTICS OF THE HNU PHOTOIONIZER

AND

ORGANIC VAPOR ANALYZER

I. INTRODUCTION

The HNU Photoionizer* and the Foxboro Organic Vapor Analyzer* (OVA) are used in the field to detect a variety of compounds in air. The two instruments differ in their modes of operation and in the number and types of compounds they detect (Table I-1). Both instruments can be used to detect leaks of volatile substances from drums and tanks, determine the presence of volatile compounds in soil and water, make ambient air surveys, and collect continuous air monitoring data. If personnel are thoroughly trained to operate the instruments and to interpret the data, these instruments can be valuable tools for helping to decide the levels of protection to be worn, assist in determining other safety procedures, and determine subsequent monitoring or sampling locations.

II. OVA

The OVA operates in two different modes. In the survey mode, it can determine approximate total concentration of all detectable species in air. With the gas chromatograph (GC) option, individual components can be detected and measured independently, with some detection limits as low as a few parts per million (ppm).

In the GC mode, a small sample of ambient air is injected into a chromatographic column and carried through the column by a stream of hydrogen gas. Contaminants with different chemical structures are retained on the column for different lengths of time (known as retention times) and hence are detected separately by the flame ionization detector. A strip chart recorder can be used to record the retention times, which are then compared to the retention times of a standard with known chemical constituents. The sample can either be injected into the column from the air sampling hose or injected directly with a gas-tight syringe.

(*) The use of any trade names does not imply their endorsement by the U.S. Environmental Protection Agency.

TABLE I-1

COMPARISON OF THE OVA AND HNU

ACTION	OVA	HNU
Response	Responds to many organic gases and vapors.	Responds to many organic and some inorganic gases and vapors.
Application	In survey mode, measures total concentration of detectable gases and vapors. In GC mode, identifies and measures specific compounds.	In survey mode, measures total concentration of detectable gases and vapors.
Detector	Flame ionization detector (FID)	Photoionization detector (PID)
Limitations	Does not respond to inorganic gases and vapors. Kit available for temperature control.	Does not respond to methane. Does not detect a compound if probe has a lower energy than compound's ionization potential.
Calibration gas	Methane	Isobutylene
Ease of operation	Requires experience to interpret correctly, especially in GC mode.	Fairly easy to use and interpret.
Detection limits	0.1 ppm (methane)	0.1 ppm (benzene)
Response time	2-3 seconds (survey mode) for CH_4	3 seconds for 90% of total concentration of benzene.
Maintenance	Periodically clean and inspect particle filters, valve rings, and burner chamber. Check calibration and pumping system for leaks. Recharge batteries after each use.	Clean UV lamp frequently. Check calibration regularly. Recharge batteries after each use.
Useful range	0-1000 ppm	0-2000 ppm
Service life	8 hours; 3 hours with strip chart recorder.	10 hours; 5 hours with strip chart recorder.

In the survey mode, the OVA is internally calibrated to methane by the manufacturer. When the instrument is adjusted to manufacturer's instructions it indicates the true concentration of methane in air. In response to all other detectable compounds, however, the instrument reading may be higher or lower than the true concentration. Relative response ratios for substances other than methane are available.

To correctly interpret the readout, it is necessary to either make calibration charts relating the instrument readings to the true concentration or to adjust the instrument so that it reads correctly. This is done by turning the ten-turn gas-select knob, which adjusts the response of the instrument. The knob is normally set at 3.00 when calibrated to methane. Calibration to another gas is done by measuring a known concentration of a gas and adjusting the gas select knob until the instrument reading equals that concentration.

The OVA has an inherent limitation in that it can detect only organic molecules. Also, it should not be used at temperatures lower than about 40 degrees Fahrenheit because gases condense in the pump and column. It has no column temperature control, (although temperature control kits are available) and since retention times vary with ambient temperatures for a given column, determinations of contaminants are difficult. Despite these limitations, the GC mode can often provide tentative information on the identity of contaminants in air without relying on costly, time-consuming laboratory analysis.

III. HNU

The HNU portable photoionizer detects the concentration of organic gases as well as a few inorganic gases. The basis for detection is the ionization of gaseous species. Every molecule has a characteristic ionization potential (I.P.) which is the energy required to remove an electron from the molecule, yielding a positively charged ion and the free electron. The incoming gas molecules are subjected to ultraviolet (UV) radiation, which is energetic enough to ionize many gaseous compounds. Each molecule is transformed into charged ion pairs, creating a current between two electrodes.

Three probes, each containing a different UV light source, are available for use with the HNU. Ionizing energies of the probe are 9.5, 10.2, and 11.7 electron volts (eV). All three detect many aromatic and large molecule hydrocarbons. The

10.2 eV and 11.7 eV probes, in addition, detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2 eV probe is the most useful for environmental response work, as the lamp's service life is longer than the 11.7 eV probe and it detects more compounds than the 9.5 eV probe.

The HNU factory calibration gas is benzene. The span potentiometer (calibration) knob is turned to 9.8 for benzene calibration. A knob setting of zero increases the response to benzene approximately tenfold. As with the OVA, the instrument's response can be adjusted to give more accurate readings for specific gases and eliminate the necessity for calibration charts.

While the primary use of the HNU is as a quantitative instrument, it can also be used to detect certain contaminants, or at least to narrow the range of possibilities. Noting instrument response to a contaminant source with different probes can eliminate some contaminants from consideration. For instance, a compound's ionization potential may be such that the 9.5 eV probe produces no response, but the 10.2 eV and 11.7 eV probes do elicit a response. The HNU does not detect methane or inorganic compounds.

The HNU is easier to use than the OVA. Its lower detection limit is also in the low ppm range. The response time is rapid; the meter needle reaches 90% of the indicated concentration in 3 seconds for benzene. It can be zeroed in a contaminated atmosphere and does not detect methane.

IV. GENERAL CONSIDERATIONS

Both of these instruments can monitor only certain vapors and gases in air. Many nonvolatile liquids, toxic solids, particulates, and other toxic gases and vapors cannot be detected. Because the types of compounds that the HNU and OVA can potentially detect are only a fraction of the chemicals possibly present at an incident, a zero reading on either instrument does not necessarily signify the absence of air contaminants.

The instruments are non-specific, and their response to different compounds is relative to the calibration setting. Instrument readings may be higher or lower than the true concentration. This can be an especially serious problem when monitoring for total contaminant concentrations if several different compounds are being detected at once. In addition, the response of these instruments is not linear over the entire detection range. Care must therefore be taken when interpreting the data. All identifications should be reported as tentative until they can be confirmed by more precise analysis. Concentrations should be reported in terms of the calibration gas and span potentiometer or gas-select-knob setting.

Since the OVA and HNU are small, portable instruments, they cannot be expected to yield results as accurate as laboratory instruments. They were originally designed for specific industrial applications. They are relatively easy to use and interpret when detecting total concentrations of individually known contaminants in air, but interpretation becomes extremely difficult when trying to quantify the components of a mixture. Neither instrument can be used as an indicator for combustible gases or oxygen deficiency.

The OVA (Model 128) is certified by Factory Mutual to be used in Class I, Division 1, Groups A,B,C, and D environments. The HNU is certified by Factory Mutual for use in Class I, Division 2, Groups, A, B, C, and D.

APPENDIX II

RATIONALE FOR RELATING TOTAL ATMOSPHERIC VAPOR/GAS CONCENTRATIONS TO THE SELECTION OF THE LEVEL OF PROTECTION

I. INTRODUCTION

The objective of using total atmospheric vapor/gas concentrations for determining the appropriate Level of Protection is to provide a numerical criterion for selecting Level A, B, or C. In situations where the presence of vapors or gases is not known, or if present, the individual components are unknown, personnel required to enter that environment must be protected. Until the constituents and corresponding atmospheric concentrations of vapor, gas, or particulate can be determined and respiratory and body protection related to the toxicological properties of the identified substances chosen, total vapor/gas concentration, with judicious interpretation, can be used as a guide for selecting personnel protection equipment.

Although total vapor/gas concentration measurements are useful to a qualified professional for the selection of protective equipment, caution should be exercised in interpretation. An instrument does not respond with the same sensitivity to several vapor/gas contaminants as it does to a single contaminant. Also since total vapor/ gas field instruments "see" all contaminants in relation to a specific calibration gas, the concentration of unknown gases or vapors may be over or under-estimated.

Suspected carcinogens, particulates, highly hazardous substances, infectious wastes, or other substances that do not elicit an instrument response may be known or suspected to be present. Therefore, the protection level should not be based solely on the total vapor/gas criterion. Rather, the level should be selected, case-by-case, with special emphasis on potential exposure from the chemical and toxicological characteristics of the known or suspected material.

II. FACTORS FOR CONSIDERATION

In utilizing total atmospheric vapor/gas concentrations as a guide for selecting a Level of Protection, a number of other factors should also be considered:

- The uses, limitations, and operating characteristics of the monitoring instruments must be recognized and understood. Instruments such as the HNU Photoionizer, Foxboro Organic Vapor Analyzer (OVA), MIRAN Infrared Spectrophotometer, and others do not respond identically to the same concentration of a substance or respond to all substances. Therefore, experience, knowledge, and good judgement must be used to complement the data obtained with instruments.

- Other hazards may exist such as gases not detected by the HNU or OVA, (i.e. phosgene, cyanides, arsenic, chlorine), explosives, flammable materials, oxygen deficiency, liquid/solid particles, and liquid or solid chemicals.

- Vapors/gases with a very low Threshold Limit Value (TLV) or Immediately Dangerous to Life and Health (IDLH) value could be present. Total readings on instruments, not calibrated to these substances, may not indicate unsafe conditions.

- The risk to personnel entering an area must be weighed against the need for entering. Although this assessment is largely a value judgment, it requires a conscientious balancing of the variables involved and the risk to personnel against the need to enter an unknown environment.

- The knowledge that suspected carcinogens or substances extremely toxic or destructive to skin are present or suspected to be present (which may not be reflected in total vapor/gas concentration) requires an evaluation of factors such as the potential for exposure, chemical characteristics of the material, limitation of instruments, and other considerations specific to the incident.

- What needs to be done on-site must be evaluated. Based upon total atmospheric vapor concentrations, Level C protection may be judged adequate; however, tasks such as moving drums, opening containers, and bulking of materials, which increase the probability of liquid splashes or generation of vapors, gases, or particulates, may require a higher level of protection.

- Before any respiratory protective apparatus is issued, a respiratory protection program must be developed and implemented according to recognized standards (ANSI Z88.2-1980).

III. LEVEL A PROTECTION (500 to 1,000 PPM ABOVE BACKGROUND)

Level A protection provides the highest degree of respiratory tract, skin, and eye protection if the inherent limitations of the personnel protective equipment are not exceeded. The range of 500 to 1,000 parts per million (ppm) total vapors/gases concentration in air was selected based on the following criteria:

- Although Level A provides protection against air concentrations greater than 1,000 ppm for most substances, an operational restriction of 1,000 ppm is established as a warning flag to:
    - Evaluate the need to enter environments with unknown concentrations greater than 1,000 ppm.
    - Identify the specific chemical constituents contributing to the total concentration and their associated toxic properties.
    - Determine more precisely the concentrations of constituent chemicals.
    - Evaluate the calibration and/or sensitivity error associated with the instrument(s).
    - Evaluate instrument sensitivity to wind velocity, humidity temperature, etc.
- A limit of 500 ppm total vapors/gases in air was selected as the value to consider upgrading from Level B to Level A. This concentration was selected to fully protect the skin until the constituents can be identified and measured and substances affecting the skin excluded.
- The range of 500 to 1,000 ppm is sufficiently conservative to provide a safe margin of protection if readings are low due to instrument error, calibration, and sensitivity; if higher than anticipated concentrations occur; and if substances highly toxic to the skin are present.

With properly operating portable field equipment, ambient air concentrations approaching 500 ppm have not routinely been encountered on hazardous waste sites. High concentrations have been encountered only in closed buildings, when containers were being opened, when personnel were working in the spilled contaminants, or when organic vapors/gases were released in transportation accidents. A decision to require Level A protection should also consider the negative aspects: higher probability of accidents due to cumbersome equipment, and most importantly, the physical stress caused by heat buildup in fully encapsulating suits.

IV. LEVEL B PROTECTION (5 to 500 ABOVE BACKGROUND)

Level B protection is the minimum Level of Protection recommended for initially entering an open site where the type, concentration, and presence of airborne vapors are unknown. This Level of Protection provides a high degree of respiratory protection. Skin and eyes are also protected, although a small portion of the body (neck and sides of head) may be exposed. The use of a separate hood or hooded, chemical-resistant jacket would further reduce the potential for exposure to this area of the body. Level B impermeable protective clothing also increases the probability of heat stress.

A limit of 500 ppm total atmospheric vapor/gas concentration on portable field instruments has been selected as the upper restriction on the use of Level B. Although Level B personnel protection should be adequate for most commonly encountered substances at air concentrations higher than 500 ppm, this limit has been selected as a decision point for a careful evaluation of the risks associated with higher concentrations. These factors should be considered:

- The necessity for entering unknown concentrations higher than 500 ppm wearing Level B protection.

- The probability that substance(s) present are severe skin hazards.

- The work to be done and the increased probability of exposure.

- The need for qualitative and quantitative identification of the specific components.

- Inherent limitations of the instruments used for air monitoring.

- Instrument sensitivity to winds, humidity, temperature, and other factors.

V. LEVEL C PROTECTION (BACKGROUND TO 5 PPM ABOVE BACKGROUND)

Level C provides skin protection identical to Level B, assuming the same type of chemical protective clothing is worn, but lesser protection against inhalation hazards. A range of background to 5 ppm above ambient background concentrations of vapors/gases in the atmosphere has been established as guidance for selecting Level C protection. Concentrations in the air of unidentified vapors/gases approaching or exceeding 5 ppm would warrant upgrading respiratory protection to a self-contained breathing apparatus.

A full-face, air-purifying mask equipped with an organic vapor canister (or a combined organic vapor/particulate canister) provides protection against low concentrations of most common organic vapors/ gases. There are some substances against which full-face, canister equipped masks do not protect, or substances that have very low TLVs or IDLH concentrations. Many of the latter substances are gases or liquids in their normal state. Gases would only be found in gas cylinders, while the liquids would not ordinarily be found in standard containers or drums.

Every effort should be made to identify the individual constituents (and the presence of particulates) contributing to the total vapor readings of a few parts per million. Respiratory protective equipment can then be selected accordingly. It is exceedingly difficult, however, to provide constant, real-time identification of all components, with concentrations of a few parts per million, in a vapor cloud, at a site where ambient concentrations are constantly changing.

If highly toxic substances have been ruled out, but ambient levels of a few parts per million persist, it is unreasonable to assume only self-contained breathing apparatus should be worn. The continuous use of air-purifying masks in vapor/gas concentrations of a few parts per million gives a reasonable assurance that the respiratory tract is protected, provided that the absence of highly toxic substances has been confirmed.

Full-face, air-purifying devices provide respiratory protection against most vapors at greater than 5 ppm; however, until more definitive qualitative information is available, concentration(s) greater than 5 ppm indicates that a higher level of respiratory protection should be used. Also, unanticipated transient excursions may increase the concentrations in the environment above the limits of air-purifying devices. The increased probability of exposure due to the work being done may require Level B protection, even though ambient levels are low.

VI. INSTRUMENT SENSITIVITY

Although the measurement of total vapor/gas concentrations can be a useful adjunct to professional judgment in the selection of an appropriate Level of Protection, caution should be used in the interpretation of the measuring instrument's readout. The response of an instrument to a gas or vapor cloud containing two or more substances does not provide the same sensitivity as measurements involving the individual pure constituents. Hence the instrument readout may overestimate or underestimate the concentration of an unknown composite cloud. This same type of inaccuracy could also occur in measuring a single unknown substance with the instrument calibrated to a different substance. The idiosyncrasies of each instrument must be considered in conjunction with the other parameters in selecting the protection equipment needed.

Using the total vapor/gas concentration as a criterion used to determine Levels of Protection should provide protection against concentrations greater than the instrument's readout. However, when the upper limits of Level C and B are approached, serious consideration should be given to selecting a higher Level of Protection. Cloud constituents must be identified as rapidly as possible and Levels of Protection based on the toxic properties of the specific substances identified.

VII. EXPLANATION OF PHRASE TOTAL ATMOSPHERIC VAPOR/GAS CONCENTRATION

The phrase "total atmospheric vapor/gas concentration" is commonly used to describe the readout, in ppm, on PIDs and FIDs. More correctly it should be called a dial reading or needle deflection. In atmospheres that contain a single vapor/gas or mixtures of vapors/gases that have not been identified, the instruments do not read the total vapors/gases present only the instrument's response. This response, as indicated by a deflection of the needle in the dial, does not indicate the true concentration. Accurate dial readings can only be obtained by calibrating the instrument to the substance being measured.

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